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?

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.

It’s not just for babies anymore...

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, cardiomyotomy, and cannulae
  - Microemboli can form as particles from the oxygenator, platelet aggregates, or fibrin aggregates

B. Humoral
- Factor XII (Hageman factor), the alternative complement cascade (C5a), 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 cytotoxins and free radicals which increase vasoreactivity 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 (18-20°C) 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 edematous injury seems to be greater than functional injury

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

Indications for ECMO
- 1. Cardiac Failure
- 2. Respiratory Failure
- 3. Cardiac and Respiratory Failure
- 4. High Risk Cath Lab Procedures
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

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

Veno-Venous ECMO

Vve-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

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 \( \geq 3 \) or uncompensated hypercapnea with \( \text{pH} < 7.20 \)

- Exclusion – PIP > 30 cmH2O or FiO2 > 0.80 for more than 7 days

Murray Score

<table>
<thead>
<tr>
<th>Element</th>
<th>Score</th>
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<tbody>
<tr>
<td>PaO2 (mmHg)</td>
<td>2</td>
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<tr>
<td></td>
<td>PaCO2 (mmHg)</td>
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<tr>
<td></td>
<td>Number of major organ failures</td>
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<td>PaO2/FiO2 (mmHg)</td>
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<td></td>
<td>Compliance (ml/cmH2O x 2)</td>
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<tr>
<td></td>
<td>PaCO2/FiO2 (mmHg)</td>
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<td>SaO2 (%)</td>
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- 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
- 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

- 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

Veno-Arterial ECMO: Indications

• Cardiogenic Shock
  - Acute Myocardial Infarction
  - S/P Cardiomyopathy
  - Acute on Chronic Heart Failure
  - Fulminant (acute)
  - Myocarditis
  - Post Partum Myocarditis
  - RV Failure after LVAD implant
  - Acute Rejection after Heart Surgery

• High Risk Interventions
  - P T C A

• 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)

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
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

- 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 > 60: DECREASE rate by 100 units/hr

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 Coagu, 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

• 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

Best practices for ECMO patient management
ECMO PROGRAM
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/](http://www.elsonet.org/)
  – Guidelines for ECMO centers
  – Patient Specific Guidelines
  – General Guidelines for all ECLS cases