ECMO 101 (and the kidney)

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2019 Disclosures

- Edwards Lifesciences
- FAST Biomedical
- Astellas
- No off label comments
What I can’t do in 20 minutes..

• Review the entire literature regarding the evidence for ECMO support
• Review different modalities to provide support for organ dysfunction
• So instead we’ll do: ECMO Made Easy
  – Concepts are easy
  – Details and experience really matter
Goals

• ECMO alphabet soup – what do the letters mean?
• Basics of the circuit
• Cannulation options
• Indications and contraindications
• Managing the patient and pump
What is ECMO?

• Extra Corporeal Membrane Oxygenation
• Used for cardiac and/or respiratory support
• Very similar to cardiopulmonary bypass (Gibbon 1953), first bedside use 1970s
• Polymethyl pentene (PMP) oxygenator technology has transformed the technique into a survivable procedure
• VA: Veno–Arterial: – support for both lungs and heart
• VV: Veno–Venous: – support for lungs only
• Unlike CPB, ECMO has no blood reservoir
What is ECMO?

Basic principle:

• De-saturated blood is drained via (one or more) venous cannulae
• \( \text{CO}_2 \) is removed, \( \text{O}_2 \) added via an oxygenator
• Blood is then returned to systemic circulation via another vein (VV ECMO) or artery (VA ECMO)
Physiology of ECLS: VA ECMO

• Replaces/augments both pulmonary and cardiac function
• Perfusate mixes in the aorta with blood from left ventricle (arriving from compromised lungs); thus $O_2/CO_2$ content = content of blood returning from the circuit + that of pulmonary source
  – NB Harlequin syndrome with periph VA ECMO
• Systemic blood flow = ECMO flow + pt’s own Cardiac Output
Harlequin Syndrome

Deoxygenated Blood From LV

Oxygenated Blood From ECMO

ECMO
What does it cost?

- **ECMO Costs:**
  - Set up: $2,825,000
  - Yearly: $2,500,000
  - Cost per patient: $90,000 - $120,000

- **People Costs:**
  - Physician investment
  - Burn out
  - Resource utilization
Physiology of ECLS: VV ECMO

• Replaces/augments pulmonary function only
• Venous blood drains from, and is returned to the right atrium
• Oxygenated blood is thus delivered to the pulmonary artery and lungs – not physiological
• Goal is thus to assist the native lungs, and if necessary to replace them
• Aim to rest native lungs and prevent VILI (baro/volutrauma)
• Systemic blood flow = pt’s own Cardiac Output
ECMO Circuitry
Cannulation

• Requires at least one venous access point
• Another venous return for VV
• Arterial return for VA
• Surgical cut down (usually)
• Traditionally realm of
  – General surgeon
  – CT surgeon
Cannulation

- Femoral cut down
- Central requires sternotomy
- Bleeding can be a big problem
- Required comfort with vascular anatomy and pumps

Illustration Source: Medscape
Newer techniques

- Development of percutaneous techniques
- Newer materials
- Larger cannulas
- Pumps and oxygenators
Cannula options

Femoral arterial cannula for adult
VA or RIJ cannula for VV
(19 or 21 French)

Femoral venous cannula for adult
VA or VV
(23 or 25 French)
Guidance

- Fluoroscopy
- Echocardiography
The Avalon Elite VV ECMO Cannula
The Avalon Elite VV Cannula
Anticoagulation

- Heparin most commonly used unless proven HIT (ie both PF4 and SRA positive)
- (Bivalirudin and argatroban are very difficult to use for ECMO)
- Given systemically in the ECMO circuit
- Generally to an ACT of 200 secs or PTT 60-80 secs
- We use anti-Xa levels aiming for 0.35 as goal
Complications

Hemorrhagic
- Surgical sites
- Cannulation sites
- Gastrointestinal bleeding
- Intracranial bleeding
- Intravascular line sites

Mechanical
- Equipment failure (oxygenator, pump, etc.)
- Malpositioned cannulas
- Vessel injury
- Distal limb ischemia

Infectious
- Ventilator-associated pneumonia
- Central line-associated blood stream infections
- Catheter-associated urinary tract infections

Systemic
- Renal failure
- Encephalopathy
- Hepatic insufficiency
- Myopathy of critical illness
- Multi-organ system dysfunction
The Ultimate Complication
Candidates for ECMO

• ECMO is appropriate as a support mechanism in patients with REVERSIBLE conditions

• It does not treat the underlying condition, and is therefore acceptable only if the underlying pathology is REVERSIBLE
Cardiac Indications

- Failure to wean from CPB
- Cardiogenic shock secondary to dilated cardiomyopathy, myocarditis, and postpartum cardiomyopathy
- Post-myocardial infarction cardiogenic shock
- Acute cardiac transplant allograft rejection
- Bridge-to-heart transplantation or ventricular assist device insertion
- Obstructive shock secondary to pulmonary embolism
- Sepsis-induced myocardial depression
- Acute drug overdoses
- Support during high-risk heart catheterization procedures
- Persistent malignant arrhythmias
Respiratory Indications

1. severe hypoxemia (\(\text{PaO}_2:\text{FiO}_2\) ratio <80)
2. severe hypercarbia with acidemia (pH<7.2)
3. Excessively high inspiratory plateau pressures (>35 cm H2O)

When the underlying disease is reversible
## Contraindications

<table>
<thead>
<tr>
<th>Absolute Contraindications</th>
<th>Relative Contraindications</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unrecoverable heart function and not a candidate for heart transplantation or ventricular assist device insertion</td>
<td>Conditions that preclude anticoagulation (eg, intracranial hemorrhage, embolic stroke, preexisting coagulopathy)</td>
</tr>
<tr>
<td>Unrecoverable lung function and not a candidate for lung transplantation</td>
<td>Concomitant multiple organ system dysfunction (eg, renal, hepatic, neurologic)</td>
</tr>
<tr>
<td>Prolonged CPR with severe neurologic injury</td>
<td>Patient refusal for blood transfusion</td>
</tr>
<tr>
<td>Terminal illness such as metastatic cancer</td>
<td>Limited vascular access</td>
</tr>
<tr>
<td></td>
<td>Morbid obesity</td>
</tr>
<tr>
<td></td>
<td>Advanced age</td>
</tr>
<tr>
<td></td>
<td>Poor prior functional status</td>
</tr>
</tbody>
</table>
Volume drives outcome

About 30 cases/year improved outcomes

Decreased complications and costs

Improved utilization
# Outcomes

<table>
<thead>
<tr>
<th></th>
<th>Total</th>
<th>Survived ECMO</th>
<th>Survive to Discharge</th>
</tr>
</thead>
<tbody>
<tr>
<td>Respiratory</td>
<td>4382</td>
<td>2800 (64%)</td>
<td>2439 (56%)</td>
</tr>
<tr>
<td>Cardiac</td>
<td>3401</td>
<td>1877 (55%)</td>
<td>1349 (40%)</td>
</tr>
<tr>
<td>ECPR</td>
<td>969</td>
<td>358 (37%)</td>
<td>267 (28%)</td>
</tr>
</tbody>
</table>

*Data from ELSO ECMO registry (2013)*
ECMO Team

• Intensivist lead team
  – Heart failure Cardiologist for VA ECMO patients
  – Heart Failure Surgeon for VA ECMO patients
  – Heart failure VAD selection team
  – Other relevant personnel
    • Physical therapy
    • Hematologist
    • Respiratory therapist
    • Nursing
Combination of extracorporeal membrane oxygenation and continuous renal replacement therapy in critically ill patients: a systematic review

Han Chen¹, Rong-Guo Yu², Ning-Ning Yin¹ and Jian-Xin Zhou¹

- Separate access
- In line (hemofilter included in ECMO circuit)
- CRRT circuit dovetailed with ECMO circuit
## ECMO CRRT options

<table>
<thead>
<tr>
<th></th>
<th>In Line Hemofilter</th>
<th>CRRT machine</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ultrafiltration control</td>
<td>IV pump controlled</td>
<td>CRRT machine controlled</td>
</tr>
<tr>
<td>Metabolic Control</td>
<td>NOT if only using SCUF</td>
<td>YES</td>
</tr>
<tr>
<td>ECMO Flow</td>
<td>Blood Shunt decrease ECMO flow decreased PaO2</td>
<td>NO systemic changes</td>
</tr>
<tr>
<td>Complexity</td>
<td>Less People</td>
<td>More People</td>
</tr>
</tbody>
</table>
ECMO is better if you can avoid CRRT
Conclusions

• ECMO is a viable option for adults and children
  – With **REVERSIBLE** severe cardio-pulmonary dysfunction
  – It is **NOT** a pre-mortem treatment to prolong the time until death occurs

• Cannulation and anticoagulation strategies are vital parts of the technique

• If ECMO patients require CRRT then several options exist, but outcomes are worse then if CRRT can be avoided
Thank you