ECMO Basic Concepts

Anne-Marie Guerguerian
Critical Care Medicine, The Hospital for Sick Children
University of Toronto
ecls.program@sickkids.ca
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WHAT IS ECMO?

In the context of caring for the ICU patient with ECMO
Extracorporeal Life Support Systems’ Nomenclature

ECLS: ExtraCorporeal Life Support
ECMO: Extracorporeal Membrane Oxygenation

*Maquet Rotaflow™*

iLA: Interventional Lung Assist

*ILA Novalung™ by Xenios*

ECCO$_2$R: Extracorporeal Carbon Dioxide Removal

VAD: Ventricular Assist Device

*Long term - LVAD: Berlin™, Heart Mate™*

*Short term - centrifugal cVAD:*

*Maquet Rotaflow™ & Levitronix Centrimag® & Pedimag™*
ECMO is a Type of ECLS

2 Main Physiologic Functions

Pulmonary Gas Exchange through an artificial ‘lung’ or MEMBRANE

1. $O_2$ delivery to meet metabolic needs
2. Removal of $CO_2$

Care of patient on ECMO involves exposure to anticoagulation and transfusion therapy
O₂ & Air

CO₂

Membrane

Pump

ECLS System: ECMO

Return of oxygenated blood

Drainage of blood to remove CO₂

Patient
Oxygen Delivery

Key Determinants in ECLS System:

- Oxygenation by artificial membrane
- Blood flow through the circuit

Patient:

- Blood flow to the native heart & circulation
- Blood flow and oxygenation through native lungs
Exchange of O₂

Oxygenation function
- Inlet SvO₂
- FiO₂
- Membrane capacity
- Red cell exposure
gas exchange area
(duration of time)
- [Hb]
- Blood Flow

Figure modified from Brodie D, Bacchetta M.
Exchange of CO₂

Carbon dioxide removal

- Gas flow rate (L/min) called sweep flow
- CO₂ gradient
- Relatively independent of blood flow

Figure modified from Brodie D, Bacchetta M. N Engl J Med 2011;365:1905-1914 without permission
Membrane Efficiency Monitoring

Parameters

- Post membrane $O_2$
- $CO_2$ removal gradient
- Pre-post blood flow pressure

- Thrombosis & fibrin $\sim O_2 & CO_2$
- Condensation $\sim CO_2$

Figure modified from Brodie D, Bacchetta M. N Engl J Med 2011;365:1905-1914 without permission
Blood Flow From Patient to ECLS

- Pump and/or Native heart function
  - Centrifugal (or pulsatile)
- Cannula & Vascular Access
  - Drainage cannula (venous)
    - *Higher flow with ‘Larger and Shorter’ cannula*
  - Return cannula
    - *Pressures may increase with higher flow*
O₂ delivery + CO₂ removal
 +/- Extracorporeal Pump
Cannulation

Vascular access:
  • Peripheral: neck and femoral
  • Central

Sites:
  • Single or dual or more

Cannula Types:
  • Lumens: single, dual, multiple
  • Flow rate capacity (L/min)
WHAT MODE OF ECMO?
Need: Modes & Configurations

- Cardiopulmonary failure
  - Cardiac or cardiopulmonary support
    - Veno-Arterial VA ECMO
- Respiratory failure
  - Respiratory Support
    - Veno-venous or VA ECMO
- Respiratory Support with Right Heart Failure
  - Pulmonary artery- to left atrium iLA
ECMO or iLA

ECMO: pump + membrane

iLA: membrane
ICU CARE WITH ECMO DECISION MAKING
1. Failure of pulmonary or cardiovascular or both? (Need)
2. Is the process leading to failure reversible?
3. Is it reversible within a reasonable amount of time?
4. If not reversible with recovery, is organ replacement by transplantation an option?
Indications: Purpose > Diagnosis

1. Bridge to organ recovery
   - To provide time needed for recovery of function
   - To facilitate therapy: surgery or medical

2. Bridge to receive organ transplant

3. Bridge to decision:
   - To another other type ECLS device
   - To palliative care
Customization

• Purpose
• Need: how much gas exchange and circulatory support is needed?
• Anatomy
  • Vascular anatomy and cannulation sites
  • Age & size or weight & height
• Mode: veno-venous vs. veno-arterial
• Configurations
  • Initial & alternatives anticipated to reach patient’s destination?
Considerations > Contraindications

Irreversible lung or heart disease
  • And organ transplantation is not an option
Massive active hemorrhage
  • Uncorrectable coagulopathy
  • Major acute intracranial hemorrhage
Multi-organ failure
  • E.g., Renal failure, Marrow failure
Complications - Mechanical

- Pump
- Membrane failure
- Air embolism
- Catheter related vascular or cardiac perforation
- Circuit clotting & Haemolysis
Complications

• Bleeding
  Cerebral hemorrhage or stroke
  Surgical site hemorrhage
• Ischemia & end organ multi-organ failure
  • Stroke & Limb Ischemia
  • Renal failure
  • Lung injury or failure of lung recovery
• Skin ulcerations
• Infection & systemic inflammatory syndrome
• Exposure to transfusions and other blood products
• Pain, delirium, fear, awareness if awake & NMB
Early Goals Focus

Resuscitation & Stabilization

3 Rs:

- Recovery
- Retraining
- Rehabilitation
Later Goals Focus

Weaning to separate for

- Organ recovery
- Organ transplantation
- Palliative care when there is no expected possible recovery nor transplantation

Functional Outcomes

Follow Up & Bereavement
Acute Respiratory Failure

Pneumonia < 1 week
ARDS
paCO$_2$ > 100 paO$_2$ < 80 mmHg
CMV or HFOV, prone, NMB

Bridge to Recovery
VV ECMO
Right internal jugular
Bicaval cannula
Expect 7-11 Days before recovery
Inter-hospital Transport

Bridge to facilitate transport to destination that can provide therapy
Acute Respiratory Failure

Pneumonia < 1 week
ARDS

Bridge to Recovery
Need to transport
VA ECMO
Femoral artery & vein
Cardiopulmonary Failure

- Mediastinal Mass with ALL
- Tumor Lysis Syndrome
- Arrhythmias
- Severe Pulmonary Edema

Bridge to recovery & facilitate acute therapy
VA ECMO with acute hemodialysis
Expect to weaning off < 24 hours
Acute cardiopulmonary failure

Cardiopulmonary arrest or not?
Elective or urgent

VA ECMO
To Facilitate Surgery or Therapies

Elective ECMO

• Cardiac surgery
  • Post cardiac surgery
• Complex tracheal surgeries
• Oncological surgeries
• Lung transplantation
Before Lung Transplantation

Bridge to and/ or bridge after surgery

Comprehensive assessment

Multi-system impact: physical & mental health

Vascular mapping and configurations

(Plan A, B, C,...)

Re-training
RVF Pulmonary Hypertension

End stage pulmonary hypertension

Bridge to lung transplantation

PA- LA with iLA

Expected months …
Sterile Peel-off Wrappers
Mixed Venous Monitoring Cuvette
Pump
Flow Probe Bubble Detector
Connectors
Flow Probe
Oxygenated Blood
Deoxygenated Blood
Gas Line
Negative Pressure Manometer
4-way Stopcock
Oxygenator
Blender
Pressure Manometer
3-Gang Manifold
4-way Stopcock
Heparin Infusion
Clamp
4-way Stopcock
Hemofilter

Adult oxygenator utilized with ¾" circuit
Paediatric oxygenator utilized with ¼" circuit
ECMO During a Severe Illness

- Electively or Emergently
  - Acute respiratory failure
  - Acute heart failure
    - Myocarditis
    - Pulmonary hypertension
  - Sepsis
  - Facilitate therapies & surgery
    - Pulmonary embolism
  - Resuscitation
Patient’s Journey on ECMO Starts

- Purpose
- Need
- Vascular access
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