EXTRACORPOREAL LIFE SUPPORT
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Objectives

- Review the indications for ECMO in patients with
  - Respiratory failure
  - Cardiac failure
  - Cardiorespiratory failure
What is ECLS?

- Extracorporeal membrane lung and/or cardiac support.
- A support therapy, in no way definitive.
- 2 basic types:
  - Veno-arterial ECMO
  - Veno-venous arterial ECMO.

History - John Gibbon - CP Bypass
The first report of prolonged extracorporeal support by Hill et al. – 1972
1976 – ECMO used for neonatal respiratory failure
1980 Multi-center RCT in adults (Survival < 10% in both groups)
1982 ECMO for PPHN (salvage)
EPOCHS

- 1970s: Beginnings
- 1980s: Neonatal ECMO
- 1990s: Pediatric ECMO and cardiac ECMO
- 2000s: Beginnings of adult respiratory
- 2010s: Worldwide expansion

Indications for ECMO

- Cardiac Failure Unresponsive to Traditional Therapies (post-op, cardiomyopathy, dysrhythmias)
- Respiratory Failure Unresponsive to Traditional Therapies (MAS, CDH, ARDS)
- Potentially Reversible Underlying Disease.

If the support mode that you are using is killing your patient, consider a change.
Unusual Indications for ECMO

- Surgical airway repair in compatible with endotracheal intubation or mechanical ventilation

Respiratory Disease
Respiratory ECMO Criteria

- Oxygenation Index (\(\text{MAP} \times \text{FiO}_2 \times 100\)) \(\text{PaO}_2\)
  - OI: 25 – 60 for ½ to 6 hrs.
  - \(\text{AaDO}_2\) > 610 mmHg for 8 hrs, 80% predictive of death
  - Acute deterioration (\(\text{PaO}_2 < 40\) for 2-12 hrs)
  - Metabolic acidosis: pH < 7.25 for 2 hrs or more
  - Progressive pulm HTN: RV dysfunction

Neonates - Contraindications

- **Absolute:**
  - Intracranial hemorrhage (IVH > Gr 1)
  - Lethal malformations

- **Relative:**
  - BW less than 2 kg (1.8 kg)
  - EGA < 34 weeks
  - Mechanical ventilation > 2 weeks with 100%
**Neonatal Mortality**

- Lower birth weight
- Lower gestational age
- Older age
- Higher Oxygenation Index (OI)
- Neurologic complications:
  - Rates of intracranial/neurologic abnormalities in neonates ranges from 10-59%
  - CNS Hemorrhage/Infarction: 6.5%/6.9%


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**Children Respiratory**

- AaDO₂ > 470 mmHg: 81% predictive of death without ECLS
- Acute deterioration
- Criteria have been less well defined than neonates.
**Ventilator Settings - Children**

- PIP ≤ 30 cm H₂O (< 35)
- pH ≥ 7.20 (7.10)
- PEEP alterations to achieve a FiO₂ ≤ 0.5 with S_pO₂ of 90%.

**Contraindications Children**

- Intracranial hemorrhage (size and site are important to consider)
- > 2 weeks of mechanical ventilation
- Multi-organ failure
- Hematopoietic stem cell transplant.
Pre-ECMO Vent Duration and Survival

Zabrocki L. CCM 2011, 39: 364-370

Pediatric Respiratory Failure Patients

Zabrocki L. CCM 2011, 39: 364-370
**Comorbidities and Survival**

![Chart showing comorbidities and survival rates](chart-image)

Zabrocki L. CCM 2011, 39: 364-370

**NITRIC OXIDE**

- Randomized, controlled trial of NO
- N=55
- **OI:**
  - No ECMO: 22.0 (18.4) 25.6 (14.9) 0.27
  - ECMO: 14.3 (5.9) 26.1 (19.5) 0.09
  - 12 hr: 14.7 (6.0) 24.5 (22.0)* 0.03

Bronicki RA et al. J Pediatr 2015; 166:365
Trends in use of VV ECMO

Adult Respiratory Disease

- Refractory hypoxemia
  - ARDS
  - Acute pulmonary embolism
  - Alveolar hemorrhage
  - Bronchopleural fistula
  - Pneumonia
- Refractory hypercarbia
  - Asthma
  - COPD
CESAR TRIAL

- Murray Score > 3.0
- Uncompensated hyprecarbia pH < 7.20
- Conventional management vs transfer to an ECMO center
- N = 180


Cesar Trial

- ECMO Arm: 68 (75%) received ECMO
- Survival to 6 mos without disability
  - 63% (ECMO) vs 47% (conventional) (p = 0.03)
ECCO$_2$R

- Extracorporeal CO$_2$ removal
- Because of efficiency of artificial lungs CO$_2$ removal requires less blood flow than ECMO
- 200 – 1500 cc/minute
- Can be used in concert with mechanical ventilation or as a way to liberate patients from MV.
- Asthma, COPD, ARDS

Cardiac failure
Congenital cardiac defects occur in approximately 1% of the population. ECMO can be used to stabilize babies and children prior to surgical repair/palliation. This is an especially poor idea in babies with obstructed total anomalous pulmonary venous return (TAPVR) as it cannot relieve the obstruction.

ECMO occurs in ~ 3-5% of all surgeries. Mortality: 40-65%.

Indications
- Failure to wean from CPB
- Low CO state
- Cardiac/respiratory arrest
- Pulmonary hypertension
- Shunt occlusion

Myocardial Failure

- Myocarditis and cardiomyopathy are important causes of shock in children
- These children can be supported with ECMO
- A good proportion (1/3 to 1/2) will improve and decannulate
- The remainder may be candidates for transplantation

Ingestion/Arrhythmia

- ECMO, because it can be deployed quickly and safely, provides excellent cardiorespiratory support for patients with cardiac failure due to ingestion of cardiotoxic agents or from arrhythmias – rarely produce severe cardiogenic shock. ECMO can provide the time to treat the dysrhythmias with medication or ablation.
Bridge to Cardiac Transplantation

- ECMO: Not the optimal modality
- Survival to transplantation is ~ 45%.
- Best if patients can be switched to another mode of longterm cardiac support.

Cardiac ECMO for Adults

- Easy and rapid deployment
- Associated with higher rate of complications
- Does not unload LV.
Cardiac ECMO for Adults

- Post AMI
- For massive pulmonary embolism (PE) with RV failure
- Post-cardiotomy
- Myocarditis/cardiomyopathy
- Bailout for interventional cardiology procedures.
- Pre-operative support.

ECPR

NO MATTER HOW BAD ASS YOU ARE,

YOU’LL NEVER MATCH A RACCOON RIDING AN ALLIGATOR.
Initial Report

- CPR had had very poor rates of neurologically intact survival to discharge
- 1992 – Pittsburgh Children’s
- 11 patients experienced refractory cardiac arrest
- Mean CPR time was 65 ± 9 minutes
- Mean ECMO duration was 112 ± 8 hours
- 6 (55%) survived to discharge.


ECPR Trends
Survival to d/c has ranged from 24-35% for in-hospital arrest (IHCA).
- Age is often a consideration in cannulation decisions
- Ongoing randomized controlled trial
- Also used for out-of-hospital cardiac arrest (OHCA).
- Survival rates range from 4%-29%.
- Often deployed in the ED
ECPR

- Programmatic issues are paramount (e.g. paging, situational awareness).
- Appropriate teams and easily accessible equipment must be ready
- Simulation (practice, practice, practice) especially useful.

Special Circumstances
ECMO in Children with Malignancies

- ELSO Registry, 1994-2007
- N = 107
- Median age: 3.7 yrs
- Mortality on ECLS: 58%
- 8 patients died after ECMO
- Total survival to d/c: 35%

Gow K et al. CCM 2009; 37:1308.

ECMO after Stem Cell Transplant - Children

- N = 19, 1991-2004, ELSO Registry
- Median age: 9.6 yrs (7 mos - 17.5 yrs)
- 1 patient survived (5%)

ECMO in Adults with Malignancy

- ELSO Registry
- N = 72
- Survival to d/c was 32%
- Most patients had respiratory failure
- Those with cardiac failure did better than the general population
- Infections occurred at a higher rate than other patients.


Viral/Fungal infections and Immune Suppression

- Patients with viral or fungal infections &
- With anticipation of prolonged (e.g. neutropenia) have a poor prognosis.
- Careful consideration should precede cannulation.
HIV

- Not an absolute contraindication
- The group in South Africa has had a good experience with 68% overall survival
- Even with *Pneumocystis jiroveci* pneumonia: 61% survival

Zabrocki L. CCM 2011, 39:364-370

Pediatric Respiratory ECMO

- 34% received VV ECMO
- VV use increased to 46% by 2007.
- VV survival: 67%
- VA survival: 51%
Time on ECMO Respiratory failure

Survival to Discharge and Time on ECMO

**ECMO in Sepsis**

- May be required when ARDS follows infection.
- Cardiac failure: inotrope score > 100 (e.g. epinephrine at 1 mcg/kg/min).
- Aggressive resuscitation
- Rapid deterioration despite treatment with rising lactate and multiple organ dysfunction

**Cannulation - Sepsis**

- Distributive Shock
  - High flow is necessary
  - Central cannulation has been used
- Left ventricular failure
- Right ventricular failure
- VV ECMO for Respiratory failure
Adult Sepsis

- Poorer outcomes:
  - Peripheral VA for distributive shock
  - Following cardiac arrest
  - Patients older than 60 years.

Trauma

- ECMO can be used to support patients with severe respiratory failure (e.g. ARDS, inhalational injury)
- ECMO can provide circulatory support to patients with failing ventricles.
- Anti-coagulation may be challenging but usually can be managed!
ECMO for trauma
- Nature of the injury
- Injury prognosis
- Possibilities for definitive repair
- Comorbidities
- Patient age
- Status of central organs (brain, liver, kidney)

Active Rehabilitation on ECMO
Tracheostomy

Foreign Bodies
The H1N1 influenza epidemic in 2011 was especially severe in pregnant women. Pregnant women are immune compromised. They may be at higher risk of ARDS. Cardiac failure is the leading cause of death in pregnant women in the UK.
Pregnancy - Management

- Permissive hypercapnia creates significant negative fetal effects.
- Pregnant women have a higher cardiac output at baseline.
- Pharmacokinetics are particularly complex in these patients.
- Heparin does not cross the placenta.
- Bleeding is common in the women, however.

Use of Liquid Ventilation