Pulmonary Hypertension & Neonatal ECMO

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Disclosures

• None
Outline

• What is ECMO?
• Why do infants need ECMO?
• When to transfer to an ECMO Center.
• Risk and Benefits.
• Management while on ECMO.
• Long term developmental outcomes.
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What is ECMO?
Two types of ECMO: VV and VA

**Venovenous**
- Improvement in cardiac function.
  - Coronaries perfused in diastole.
- Maintains pulsatile flow
- “Less” invasive
  - No carotid ligation

**Venoarterial**
- Respiratory and cardiac support
- Improved oxygen delivery
- No recirculation
- Decreases preload
Two types of ECMO: VV and VA

- Why pick on over the other?
  - Need for cardiac support is the main determinate.
The Circuit: Cannulas

- VV ECMO: One double lumen cannula
- VA ECMO: Two single lumen cannulas

Cannulation Site
- VV ECMO: Right internal jugular vein.
- VA ECMO: Right internal jugular vein and right carotid artery.
The Circuit: Cannulas

- VV Cannula
- VVDL
- Arterial
- Venous
- VA Cannulas

http://maquet-turkey.com.tr/page/urunler
The Cannulas: VVDL

Double lumen Cannula

Inflow Lumen

Drainage Lumen

Venous drainage from the patient

Recirculation from oxygenated to venous drainage site

5 cm

Oxygenated blood to the patient

http://www.annals.in/article.asp?issn=0971-9784;year=2011;volume=14;issue=3;spage=218;epage=229;aulast=Chauhan
The Circuit: VVDL Cannula

- Arterial Limb
- Venous Limb
- Duel Lumen
The Circuit: VVDL Cannula
The Circuit: VA Cannulas
The Circuit: VA Cannulas

- Venous
- Arterial
- Tip
The Circuit: The Pump

- Roller Pump
The Circuit: The Pump

- Venous drainage and siphoning occurs mainly via gravity.
- The pump can generate negative pressure to help siphon blood out of the patient.
- Provides positive pressure to push blood through the oxygenator and back to the patient.
The Circuit: The Oxygenator

Quadrox-D Oxygenator by Maquet
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Why do infants need ECMO?

- **Pulmonary Hypertension***
  - Meconium Aspiration Syndrome ................................................................. 94%
  - Surfactant Deficiency/ Respiratory Distress Syndrome ........ 84%
  - Idiopathic/Persistent Fetal Circulation ................................................. 78%
  - Congenital Diaphragmatic Hernia ......................................................... 51%

- **Infection**
  - Bacterial Sepsis .......................................................................................... 75%
  - Pneumonia .................................................................................................. 54%
  - Viral Sepsis ................................................................................................ <10%

- **Congenital Heart Disease**
  - Pre-operative
  - Post-operative: failure to wean from bypass in OR
Why do infants need ECMO: Fetal Circulation

- Decreased blood flow to lungs.
  - 10-13% of CO reaches lungs
  - Increased PVR
  - Shunting $R \rightarrow L$ though the ductus

- Umbilical veins
  - Sats approximately 70-75%
  - $\text{PaO}_2$ approximately 30-40mmHg

- Selective streaming of umbilical venous blood to the left heart
  - Right heart does most of the work in the fetus
  - Left heart perfused the coronaries and brain
**Transition at Birth**

**Ventilation of the lungs**
- Clears lung liquid
- Establishes FRC
- Stimulates surfactant
- $\uparrow$ pulmonary blood flow – 8-10 fold

**Oxygenation ($\uparrow$ $PO_2$)**
- $\uparrow$ pulmonary blood flow
- $\uparrow$ LA pressure
- Functional closure FO
- Decreases ductal R→L shunting
- Ductal constriction

**Physiologic pulmonary hypertension**

**Normal Transition**
- Pulmonary hypertension resolved

**Abnormal Transition**
- Persistent Pulmonary Hypertension

**Asphyxia, hypoxia, acidosis, hypothermia, hyperviscosity, atelectasis, lung disease**

**Cord clamping**
- $\uparrow$ Systemic vascular resistance

*Slide courtesy of Satyan Lakshminrusimha, MD*
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When to transfer to an ECMO Center?

- Many providers view the need for ECMO as a personal failure of their management.
- The need for ECMO simply reflects an increasing severity of disease process.
- ECMO is a tool and like any other tool it has a place in management.
When to transfer to an ECMO Center?

- All congenital diaphragmatic hernia (CDH) patients.
- Markers of severe respiratory failure
  - Failure to improve within 4-6 hours of high frequency ventilation or nitric oxide to an OI < 25
  - An oxygenation Index (OI) > 25
  - Mean airway pressure of > 15 cmH2O
  - Amplitude of > 35 cmH2O
- Markers of inadequate end organ perfusion
  - A plasma lactate > 25 mg/dl, and not improving on pressors
  - pH < 7.25
  - Base deficit > 5
  - Mixed venous saturation < 70%
When to transfer to an ECMO Center?

• All congenital diaphragmatic hernia (CDH) patients.

• Markers of severe respiratory failure
  – Failure to improve within 4-6 hours of high frequency ventilation or nitric oxide therapy
  – O2 extracted carbon monoxide ventilation
  – Mean airway pressure of >15 cmH2O
  – Amplitude of >35 cmH2O

• Markers of inadequate end organ perfusion
  – Plasma lactate >25 mg/dl, and not improving on pressors
  – pH <7.25
  – Base deficit >5
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Patients with congenital diaphragmatic hernia, sepsis, shock, or poor myocardial function are prone to RAPID deterioration, including death, PRIOR to meeting ECMO criteria. These patients should be transferred early, depending on the distance from the ECMO center.
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Risk and Benefits of ECMO

- **Risk**
  - Bleeding
    - Intracranial hemorrhage
    - Hemorrhagic stroke
  - Clot formation
    - Ischemic stroke
  - Vessel damage
    - Perforation
    - Stenosis

- **Benefits**
  - Allows for lung and cardiac rest.
  - Prevents high pressure damage to lung tissue
  - Allows for maximal end organ perfusion
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Management while on ECMO

• Rest the lungs
• Fluid and nutrition
  – Ensure adequate calories 50-60kcal/kg/day is usual for BMR
  – Avoid fluid overload
• Coagulation Management
  – Hematocrit and platelets
  – Heparin vs. bivalrudin
• Sedation
  – Not snowed, but not uncomfortable
Management while on ECMO

• How do we know when they are ready to come off?
  – Natural history of the disease
  – Chest x-clear
  – Oxygen challenge is good

• Trial off
  – VA – low flow and clamp trial
  – VV – unplug the oxygen
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Long Term Developmental Outcome

• Sensory neural hearing loss ➞ old data from the 1990s
• Normal intelligence
  – Deficits not different than conventionally treated peers.
    • ECMO 68% ➞ normal cognitive function
    • Conventional 70% ➞ normal cognitive function
• Attention problems
  – Information retention and processing speed are slightly lower
• Developmental follow up is needed for these infants.
• The severity of disease, not the addition of the ECMO circuit, seems to be the primary driver of neurologic outcomes.
Closing Thoughts

• ECMO is a life saving therapeutic modality for critically ill infants.

• Severity of illness is the major predictor of long term developmental outcomes.

• Consider referring to ECMO center if signs of diminished end organ perfusion despite maximal conventional therapy.
Regional ECMO Centers

Children’s Mercy
HOSPITALS & CLINICS
Kansas City
1-800-GO-MERCY

Children’s
HOSPITAL • ST. LOUIS
1-800-678-HELP

Children’s
HOSPITAL & MEDICAL CENTER
OMAHA
1-800-833-3100

Children’s Hospital Colorado
1-800-525-4871
(press 1 for Transfer Center)

Arkansas Children’s
HOSPITALS • RESEARCH • FOUNDATION
1-800-ACH-HELP
Questions?

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