ECMO: EXTRACORPOREAL CARDIOPULMONARY SUPPORT IN THE NICU

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LANDMARK REPAIR:

- John H Gibbon, MD
- Patient: Cecilia Bavolek
- Year: 1953
- Procedure: ASD repair using an extracorporeal circuit
- Original device the size of a spinet piano
Prolonged Extracorporeal Oxygenation for Acute Post-Traumatic Respiratory Failure (Shock-Lung Syndrome) — Use of the Bramson Membrane Lung
FATHER OF MODERN ECMO: DR ROBERT H. BARTLETT
CLINICAL TRIALS

- Bartlet used a strategy of “play the winner”
- O’Rourke conducted a prospective, randomized trial using 50/50 randomization strategy
NEONATAL ECMO

• A method of heart and lung bypass used for respiratory failure widely since 1982

• It requires the placement of cannulas in the major blood vessels of the neck

• Blood removed from the infant undergoes gas exchange through a membrane lung and then is rewarmed before returning to the infant
PHYSIOLOGY:
TWO TYPES OF ECMO

- VA ECMO
  - Supports heart and lung function

- VV ECMO
  - Supports lung function only
MEMBRANE LUNG GAS EXCHANGE

• **CO₂ EXCHANGE** (air flow variable)
  - Independent of blood flow
  - Dependent on gas diffusion gradient
  - Dependent on sweep gas flow rate
  - Dependent on membrane surface area

• **O₂ EXCHANGE** (blood flow variable)
  - Independent of sweep gas flow rate
  - Dependent on blood flow rate
  - Dependent on blood path thickness
  - Dependent on membrane diffusion thickness
  - Dependent on O₂ concentrations
  - Dependent on membrane surface area
NEONATES REQUIRING ECMO

• Neonates that require ecmo in the newborn time period may have a variety of illnesses

• Pulmonary hypertension is typically a secondary process of the various disease states

• The initial disease states may include:
  • *Meconium aspiration syndrome*
  • Congenital pneumonia/sepsis
  • Congenital diaphragmatic hernia
  • Idiopathic pulmonary hypertension
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NEONATAL RESPIRATORY
VA ECMO
COOLING NEONATES ON ECMO

- Therapeutic hypothermia
- More than or equal to 36 weeks GA
- Experienced a hypoxic-ischemic insult
  - Apgar ≤ 5 requiring positive pressure ventilation at 10 minutes of life
  - Umbilical vessel blood pH ≤ 7.0
  - Or base deficit at least -12 to -15.9 with fetal HR deceleration, cord prolapse or rupture, uterine rupture, severe maternal trauma, placental abruption, mother receiving CPR
  - And clinical signs of encephalopathy
NEONATAL SELECTION GUIDELINES
FOR NEONATAL RESPIRATORY ECMO

- Gestational age at least 34 weeks
- Not more than 10 days of mechanical ventilation (relative contraindication)
- Absence of severe underlying non-pulmonary disease
- Cranial ultrasound with no ICH (Grade I or subependymal ICH is a relative contraindication)
- No evidence of severe brain injury
- No evidence of uncontrolled bleeding or known bleeding diathesis
- No evidence of severe, and irreversible brain damage
NEONATAL SELECTION GUIDELINES FOR NEONATAL RESPIRATORY ECMO

- Evidence of severe, reversible lung disease

- Oxygenation index (OI) over 40 on 2 or more blood gases

- $0I = (PAW \times FiO_2 \times 100)/\text{post-ductal } PaO_2$

- Severe refractory respiratory failure with sudden decompensation ($PaO_2 < 40$ torr for 2 hours) unresponsive to maximal medical management
CONTRAINDICATIONS FOR NEONATAL RESPIRATORY ECMO

- Gestational age < 34 weeks
- Evidence of severe and irreversible brain damage
- Severe, irreversible damage to other critical organs (heart, kidney, liver)
- Bleeding that would be uncontrollable or damaging on heparin
- Grade II or greater ICH
- Life-threatening and untreatable non-pulmonary disease
- Lung disease that is unlikely reversible in 14-21 days
CONTRAINDICATIONS FOR NEONATAL RESPIRATORY ECMO

• Pre-ECMO CPR:

  • pH < 6.8 – do not offer ECMO
  • pH > 6.8 and CPR duration < 20 minutes*, consider ECMO
  • pH > 7.1 and CPR duration 20-45 minutes*, consider other factors in decision to offer ECMO
  • CPR duration > 45 minutes* - do not offer ECMO
  • If pH > 7.45 even after prolonged CPR and prognosis is improved, consider ECMO candidacy
  • *restoration of spontaneous cardiac rhythm and acceptable BP
CONTRAINDICATIONS FOR NEONATAL RESPIRATORY ECMO

• Post-ductal PaO$_2$:
  • PaO$_2$ < 20 torr for > 3 hours OR
  • PaO$_2$ < 10 torr for > 1 hour OR
  • pH < 7.0 for > 1 hour immediately following birth,

THEN do not offer ECMO because of the high risk of ICH for other severe CNS injury
RELATIVE CONTRAINDICATIONS
NEONATAL RESPIRATORY ECMO

• BW < 2.0kg
• History of invasive procedures
• Known or suspected bleeding diathesis
• Grade I ICH
• Overwhelming sepsis with capillary leak
• More than 14 days of ventilator therapy
EXCLUSIONS FOR NEONATAL RESPIRATORY ECMO

• Patients with a lethal condition in its terminal state or
• A lethal condition with a life-threatening complication of that disease
• Multi-organ system failure – pulmonary failure with failure of two other major organ systems
RELATIVE EXCLUSIONS FOR NEONATAL RESPIRATORY ECMO

- High morbidity disease state (poor predicted quality of life)
- History of CPR – see CPR guidelines
- ICH – see general neonatal guidelines
- GI bleeding
- Creatine > 3.0
- Profound shock refractory to medical management >6 hours
POTENTIAL COMPLICATIONS WITH NEONATAL RESPIRATORY ECMO

- Bleeding
- Thrombosis
- Circuit air
- Hemolysis
- Inadequate support
- Equipment failure
- Cardiac complications
- Renal complications
- Infection
- Neurological complications
- Graft versus Host Disease
- DEHP exposure
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Data provided by
NEURODEVELOPMENTAL OUTCOME OF NEONATAL ECMO

• Glass, et al:
  • At 5 years of life; mean IQ remains in the normal range, but are lower than controls (mean 96 versus 115, p < 0.001)
  • 15% of survivors have major handicaps; most commonly mental retardation
  • < 5% have severe or profound impairments
NEONATAL ECMO: SAVING LIVES