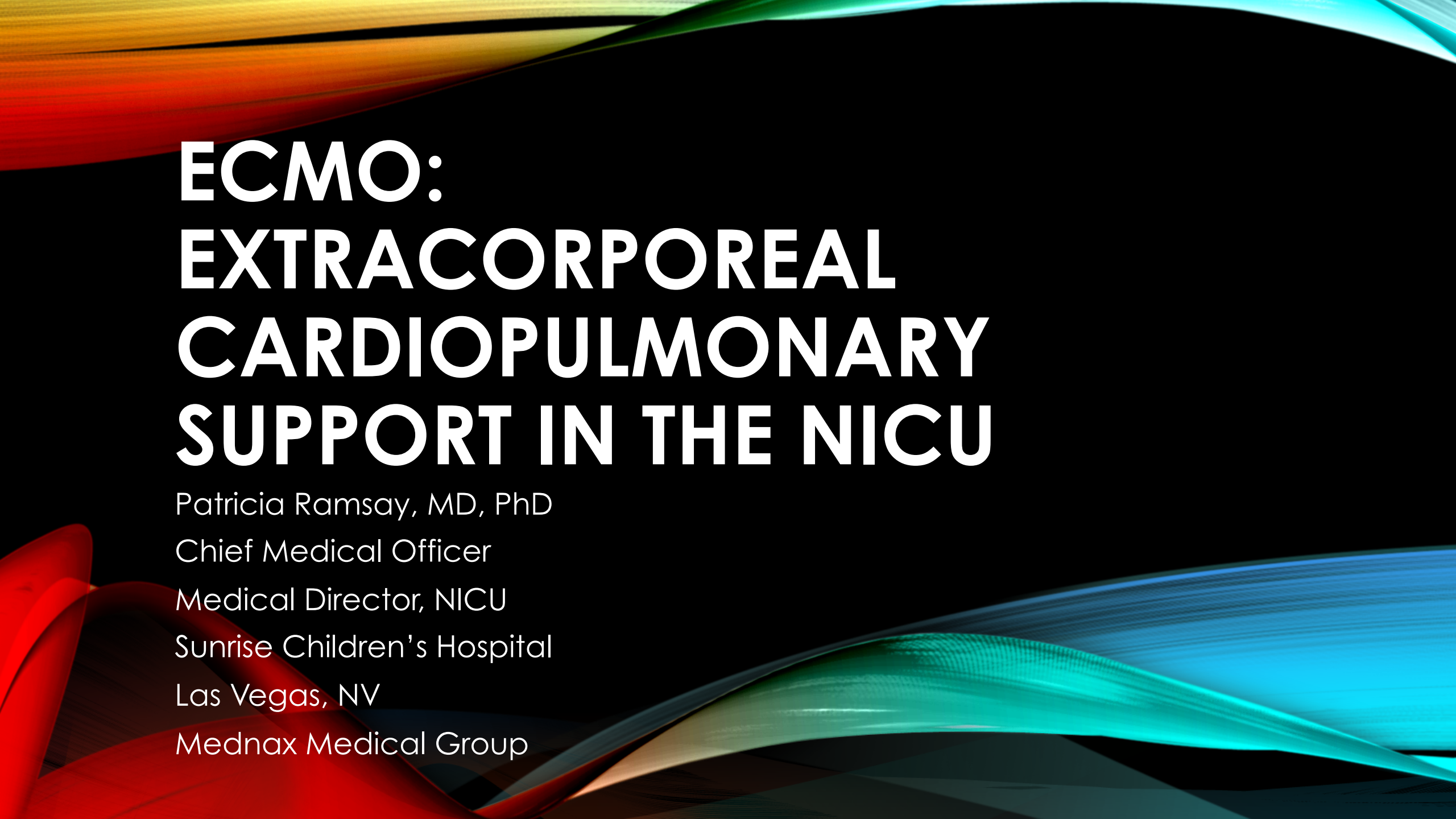




ECMO: EXTRACORPOREAL CARDIOPULMONARY SUPPORT IN THE NICU

Patricia Ramsay, MD, PhD

Chief Medical Officer

Medical Director, NICU

Sunrise Children's Hospital

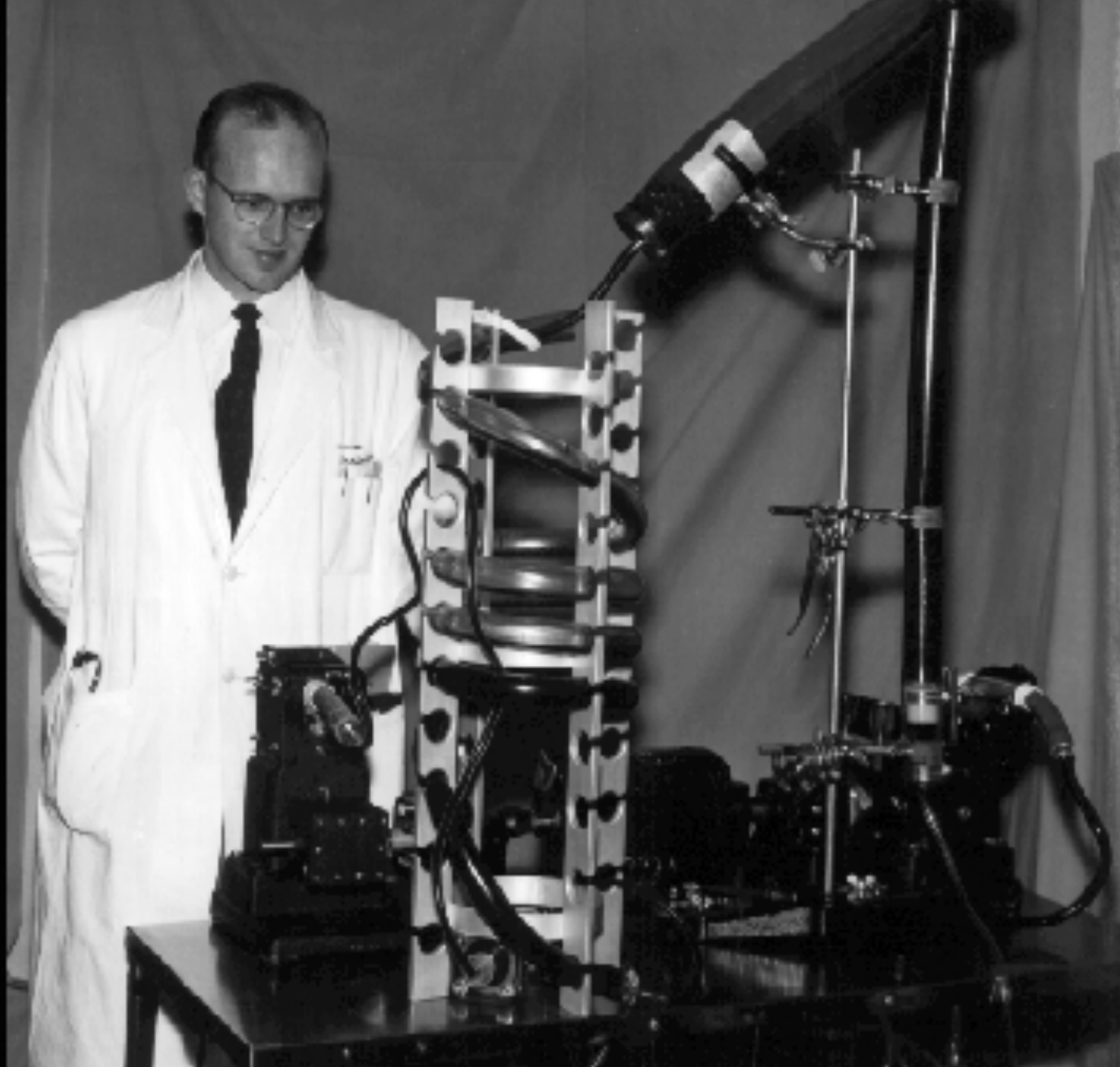
Las Vegas, NV

Mednax Medical Group

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





First successful ECMO patient in 1971



Figure 3.4. The first successful extracorporeal life support patient, treated by J. Donald Hill using the Bramson oxygenator (foreground), Santa Barbara, 1971.

NEJM 1972

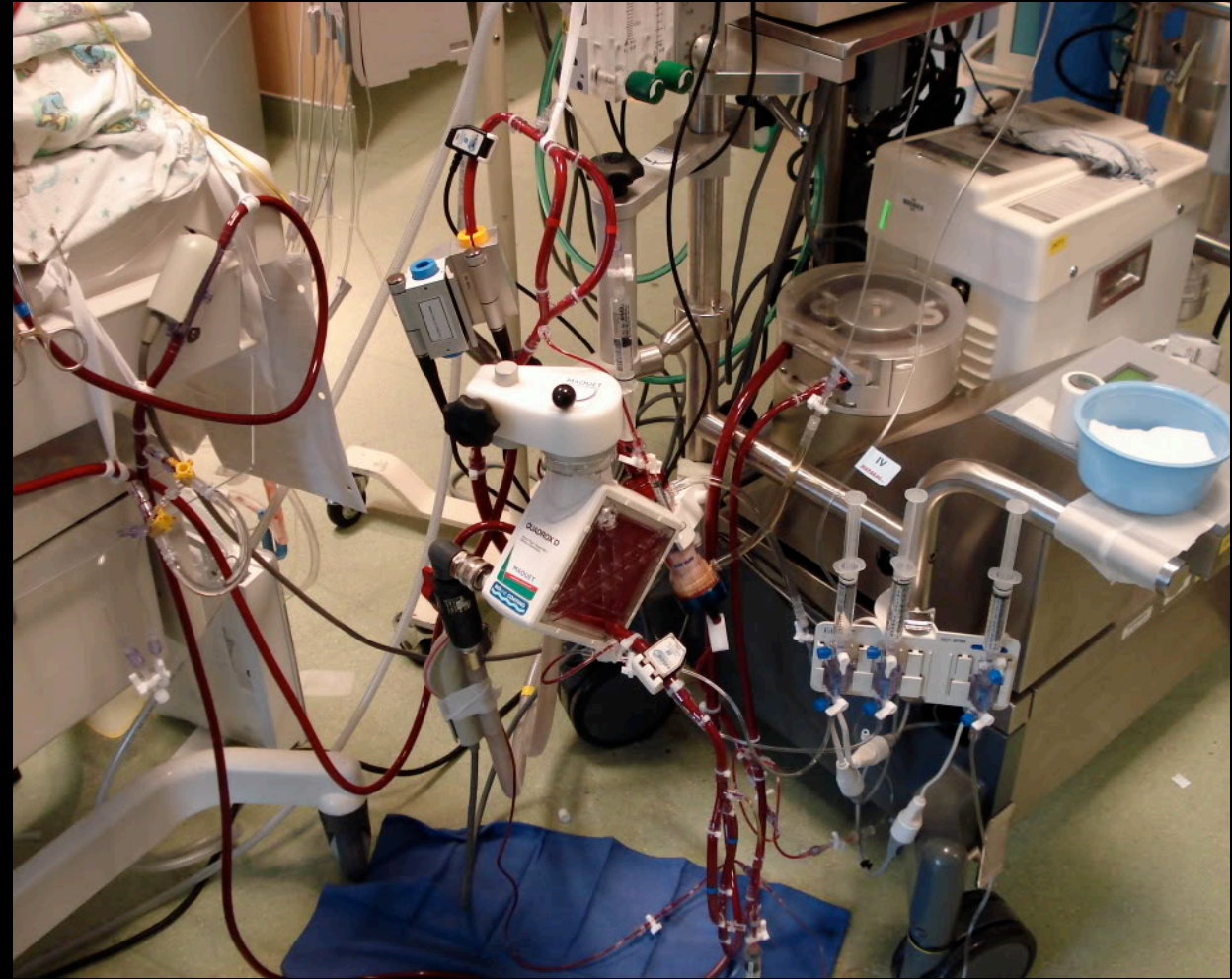
- Prolonged Extracorporeal Oxygenation for Acute Post-Traumatic Respiratory Failure (Shock-Lung Syndrome) — Use of the Bramson Membrane Lung

**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

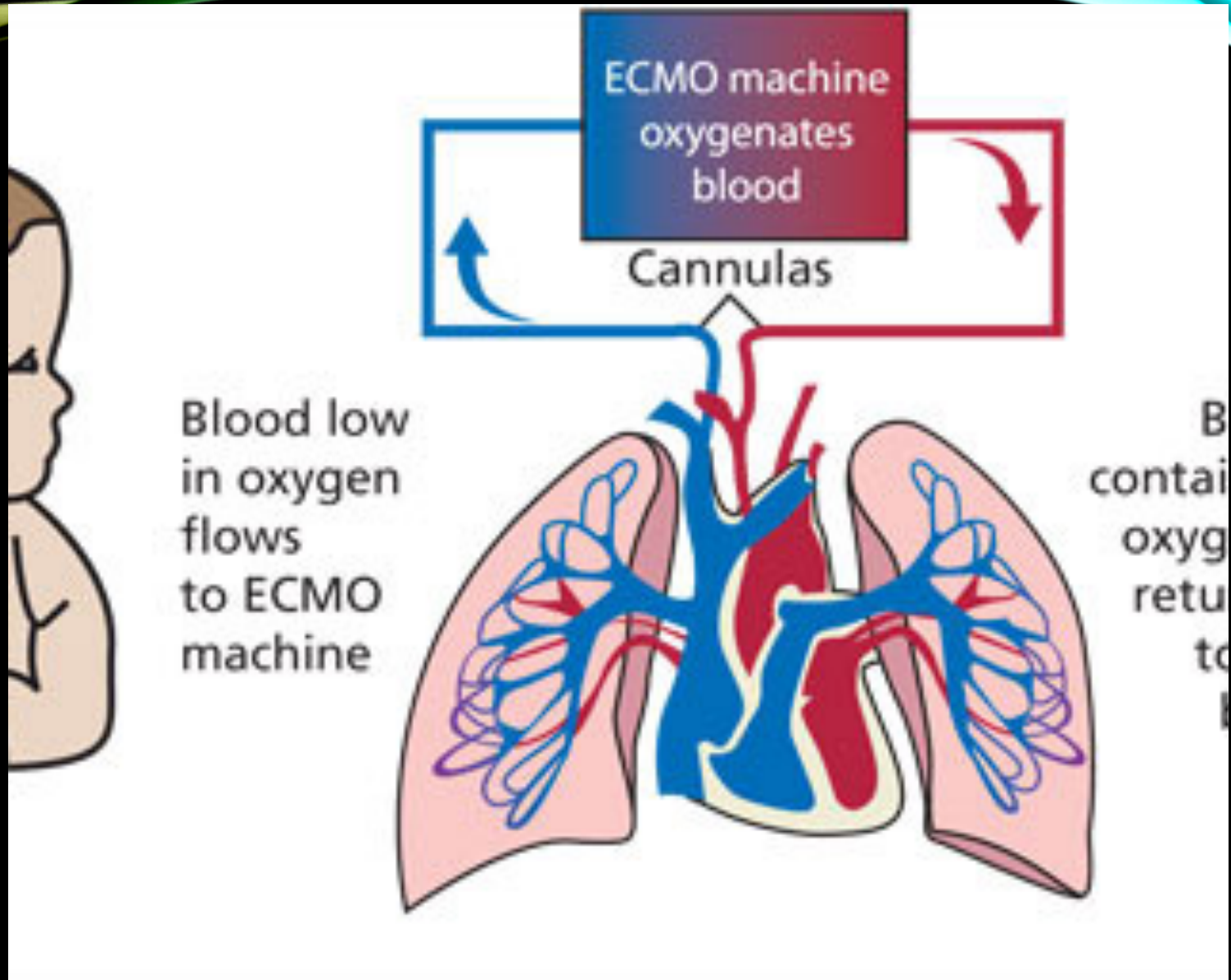
- A method of heart and lung bypass used for respiratory failure widely since **1982**
- It requires the placement of cannulas in the major blood vessels of the neck
- Blood removed from the infant under goes gas exchange through a membrane lung and then is rewarmed before returning to the infant



PHYSIOLOGY:

TWO TYPES OF ECMO

- VA ECMO
 - Supports heart and lung function
- VV ECMO
 - Supports lung function only

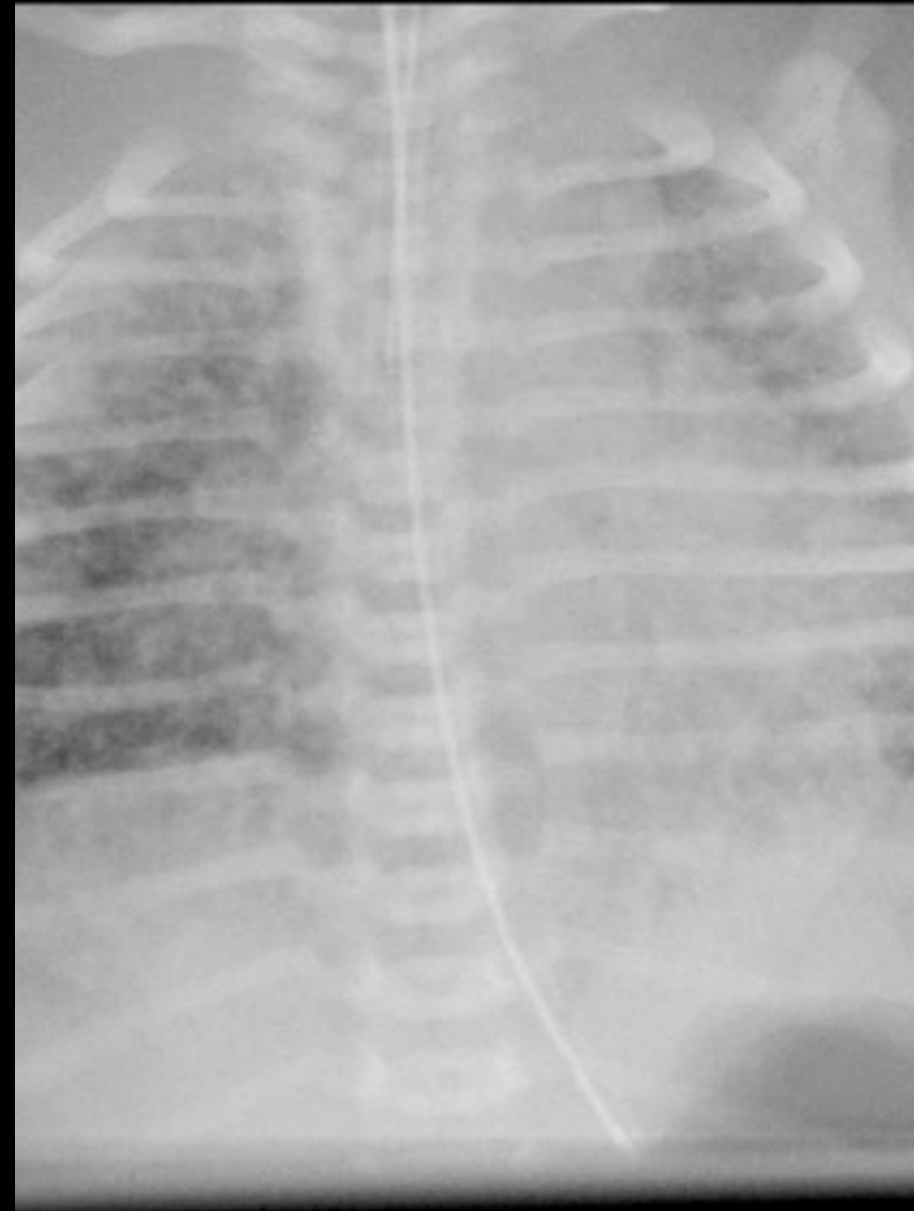


MEMBRANE LUNG GAS EXCHANGE

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

- $\text{PaO}_2 < 20$ torr for > 3 hours OR
- $\text{PaO}_2 < 10$ torr for > 1 hour OR
- $\text{pH} < 7.0$ 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

SURVIVAL BY DIAGNOSIS

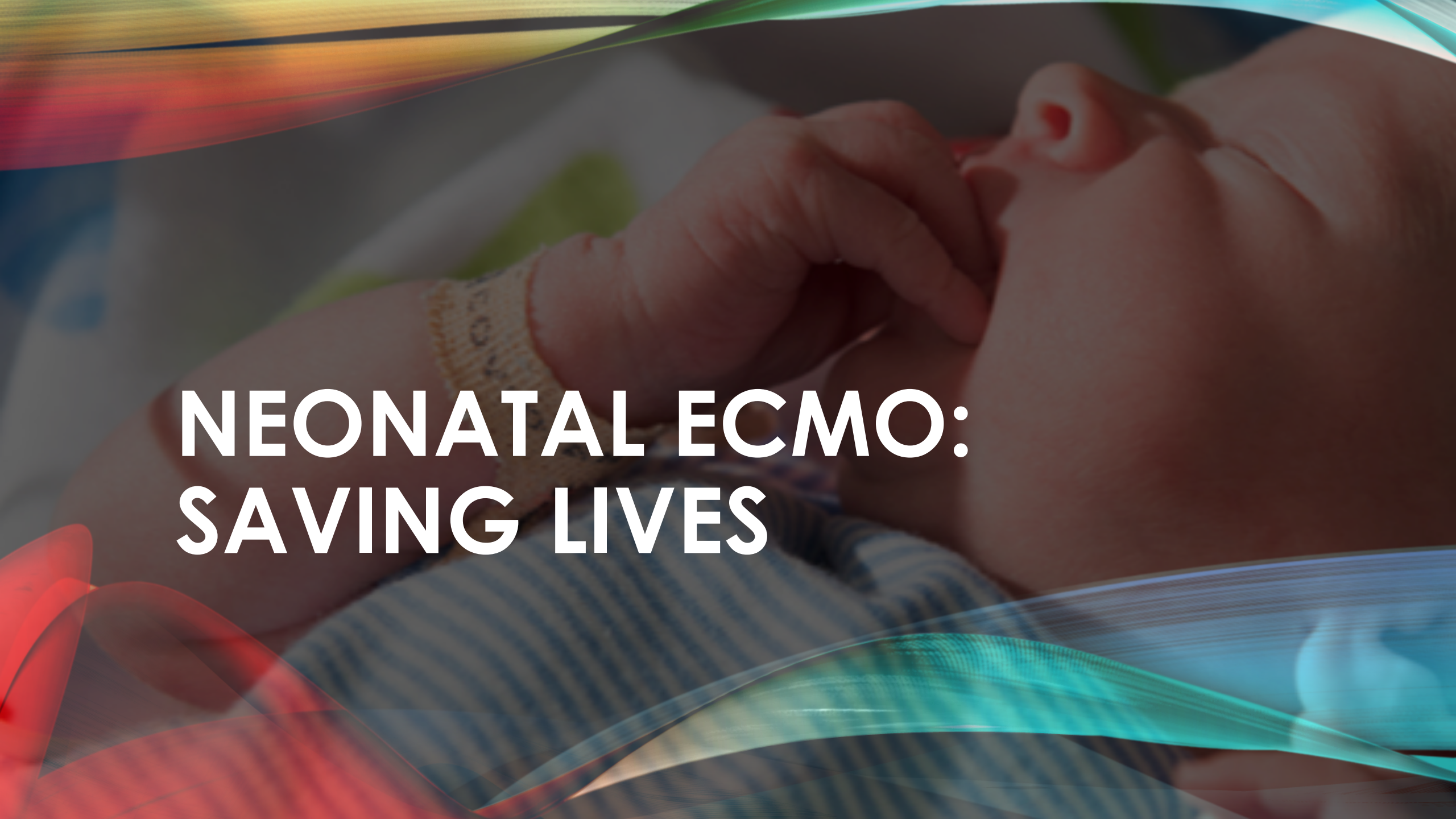
Diagnosis	Cumulative infants	Cumulative survival (%)
MAS	6805	94
CDH	4770	52
Sepsis	2699	74
PPHN	3077	78
RDS	1398	64
Other	1436	64
All	19,939	77

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