Nemours® Alfred I. duPont Hospital for Children

What is ECMO?

Chris Beaty, BSN, RN, CCRN

ECLS Coordinator, Nemours/AI duPont

Director of Perinatal Program

No disclosures

- Although, I am accepting offers……

So What is ECMO?

- **ECMO, ECLS, ECCS, MCS**
  - All terms used interchangeably
- **ECMO (ExtraCorporeal Membrane Oxygenator)**
  - Outside the body oxygenation
- **ECLS (ExtraCorporeal Life Support)**
  - Outside the body life support
    - ECMO
    - VADs

ECMO

ECMO

- A modified heart-lung bypass technique used to treat *reversible cardiopulmonary failure* that is no longer responsive to maximal conventional therapy.

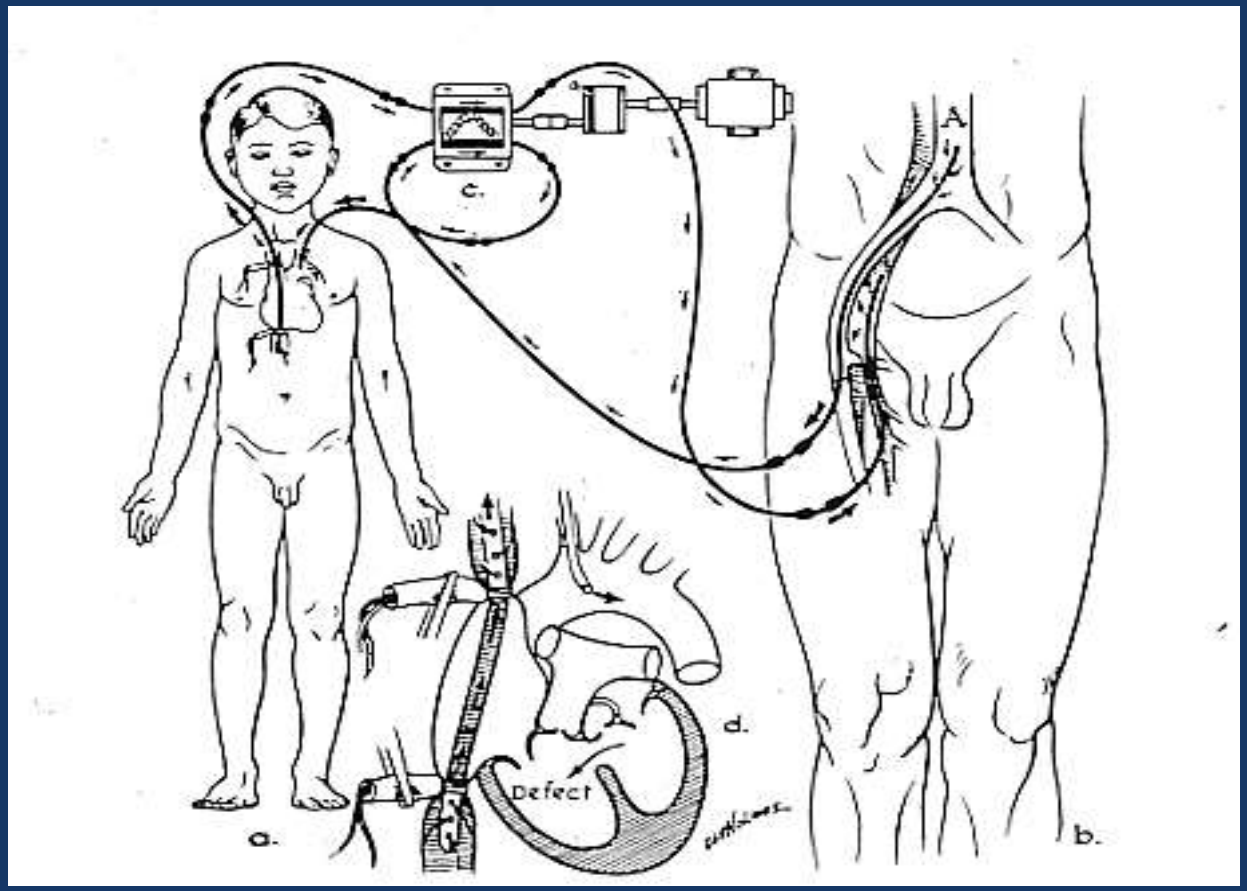
- More than 50,000 infants, children and adults treated to date.

ECMO vs. Cardio Pulmonary Bypass (CPB)

- **CPB**
  - hypothermia
  - full heart-lung bypass
  - open circuit
  - complete anticoagulation
- **ECMO**
  - normothermia
  - partial, full or no heart-lung bypass
  - closed circuit
  - partial anticoagulation

Cardiopulmonary Bypass

- Cross-Circulation

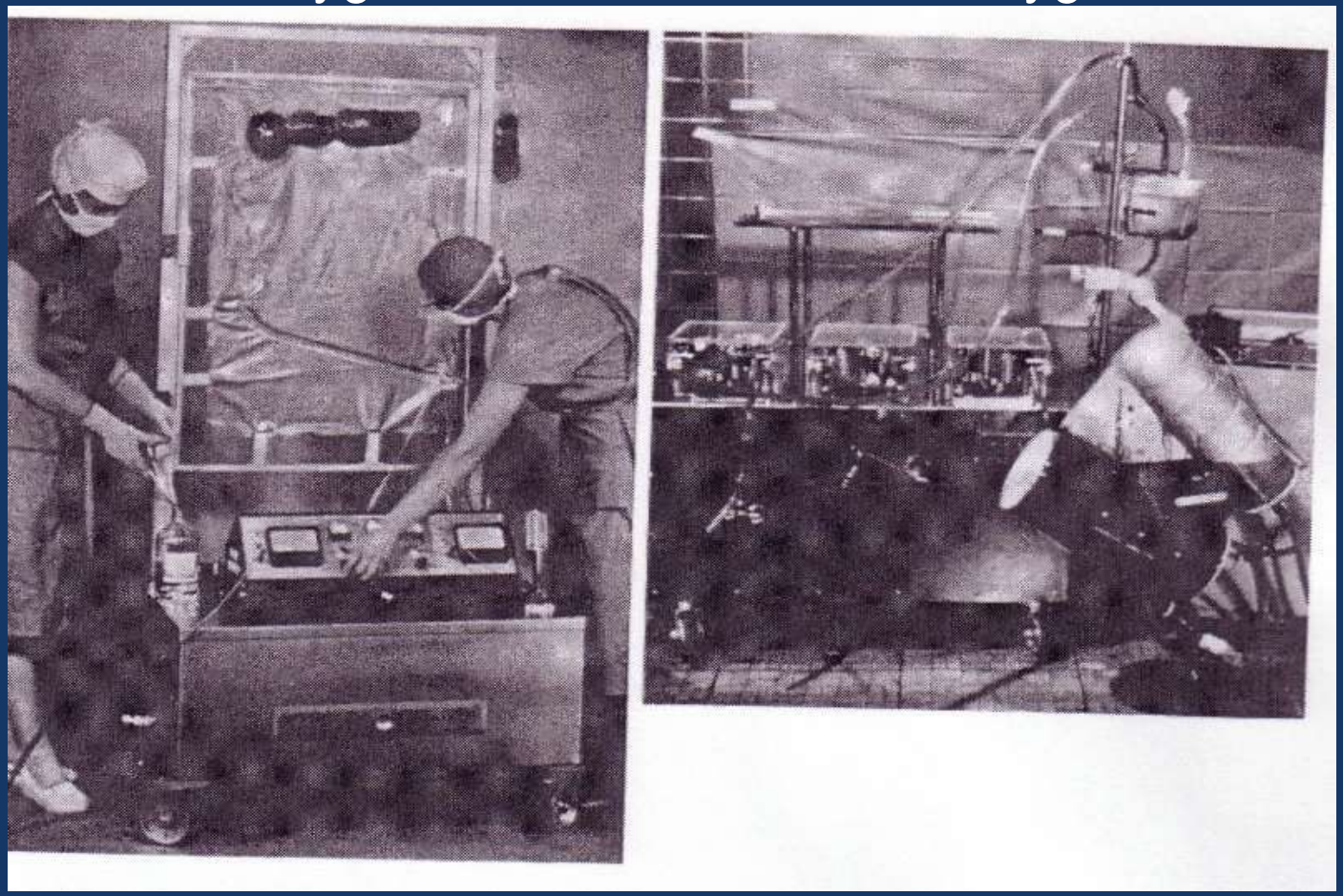


Dr. John Gibbon

Early Bypass Machines and Lungs

Sheet Oxygenator

Bubble Oxygenator



Bypass Today

History

- **Heart-Lung bypass**
  - 1930s-1950s
- **Adult ECMO**
  - 1970s
- **Neonatal ECMO**
  - Late 1970s-early 1980s

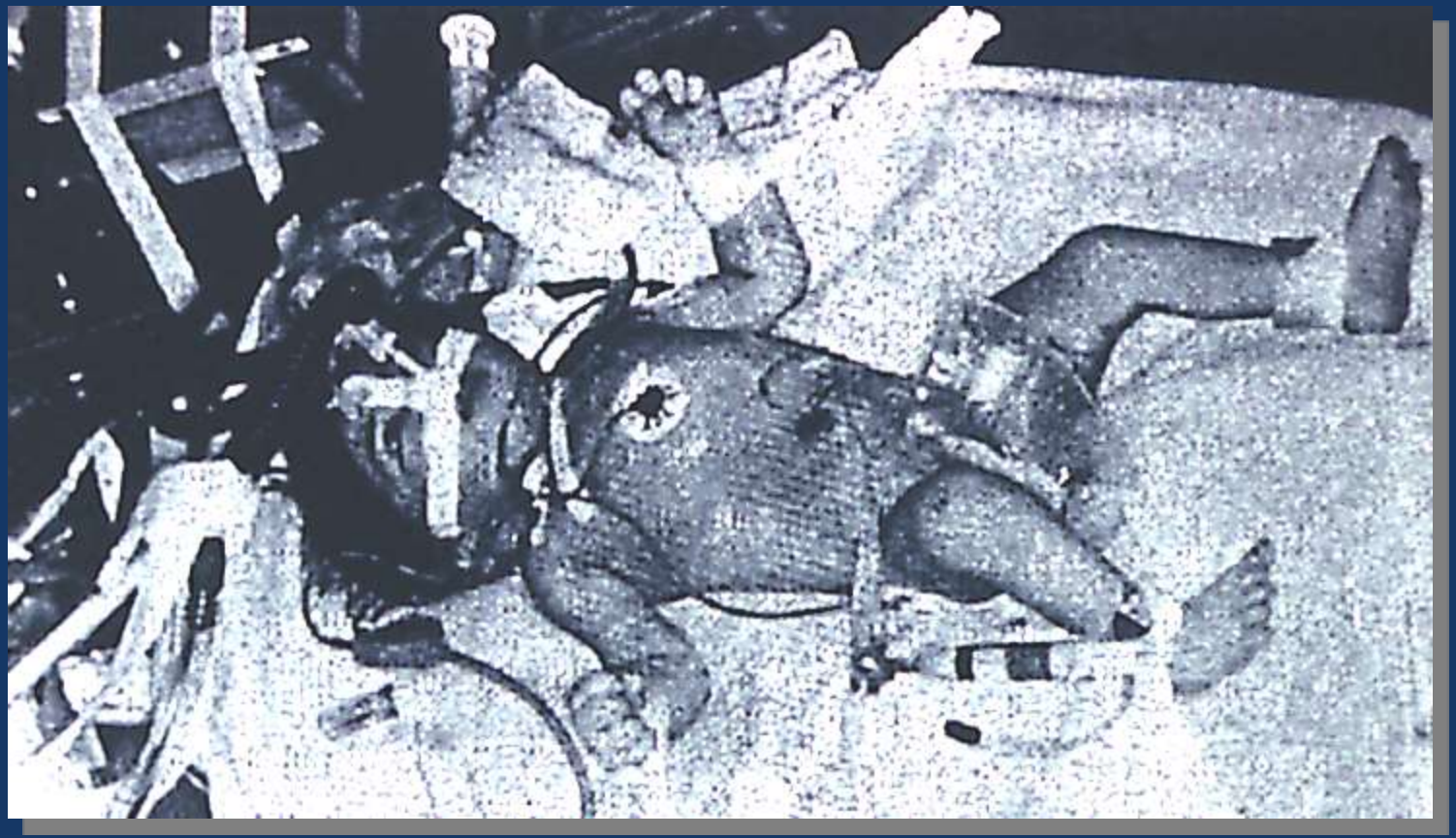
ECMO History

- **Adult ECMO came first**
- **First patient 1971**
- **NIH trial in late 1970s (HUP was a study center)**
  - Trial stopped due to poor survival
- **Interest in adult ECMO declined until late 1980s**
  - Technology & knowledge improved

Neonatal ECMO

- Dr. Robert Bartlett at U.C. Irvine
- Late 1970s through mid-1980s
- High survival rate (80%) in term babies
- High IVH rate in preterm babies

Neonatal ECMO #1
Esperanza



Nemours. Alfred I. duPont Hospital for Children

Criteria for ECMO

- **Reversible Disease.**
- **Failure to respond to maximal conventional therapy**
  - HFOV, 100%Oxygen, iNO, Inotropes
- **Failure to *improve* on maximal therapy**
- **Acute deterioration**

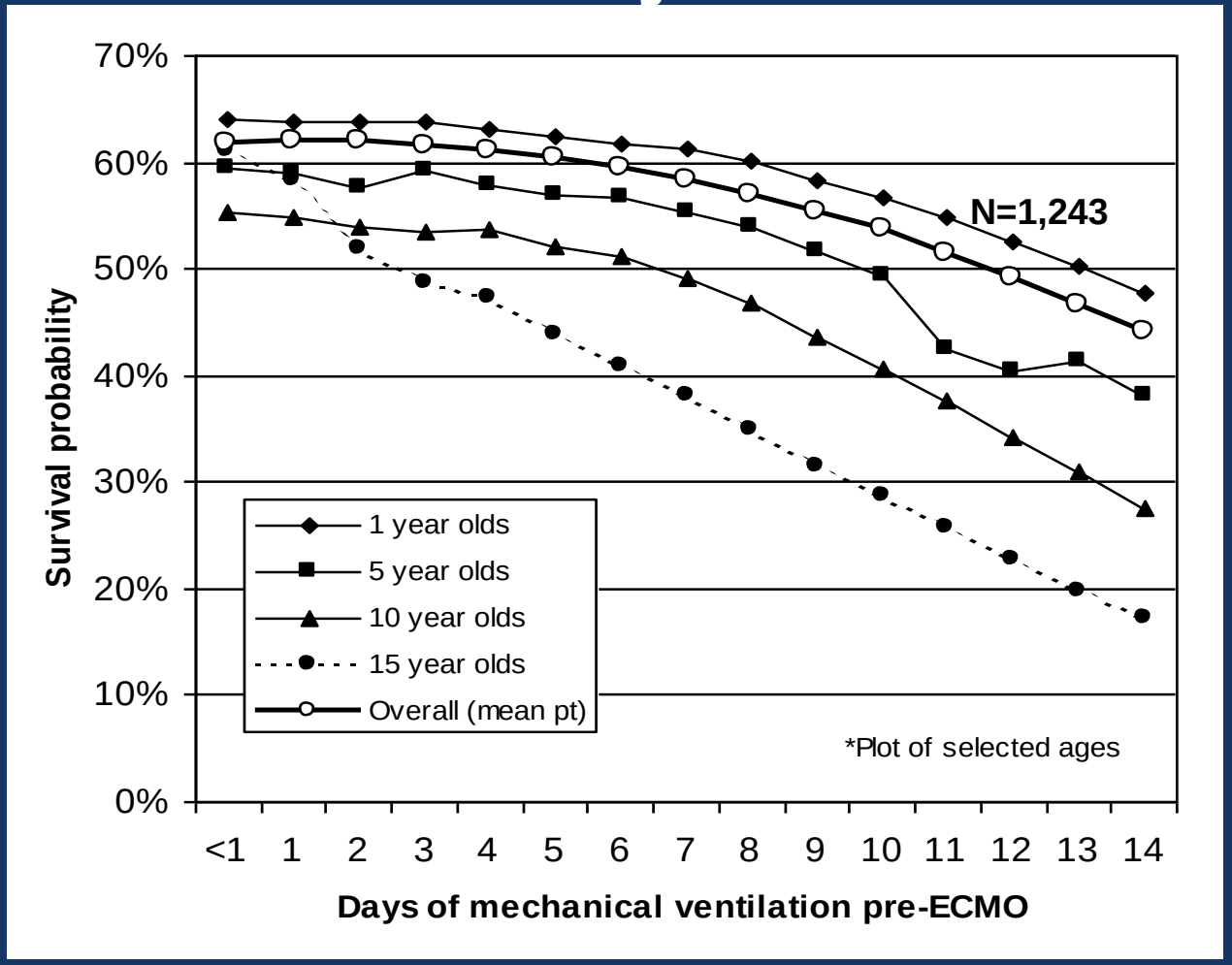
Criteria for ECMO

- **Oxygenation index > 40 OI= $\frac{\text{MAP x FiO2 x 100}}{\text{PaO2}}$**
- **A(Alveolar)-a(arterial) gradient > 600 > 6 hours**
  - A-a gradient=[(atmospheric pressure(760)-partial pressure of water vapor(47)xFiO2-(1.25PaCO2)-(Post-ductal PaO2)]
    - Simplified: 713-(1.25xPaCO2)-PaO2 assuming at sea level, normothermic and on 100% FiO2.

Contraindications

- Severe intracranial hemorrhage
- Non-reversible coagulopathy
- Prematurity (< 34 weeks)???
- Multi-organ system failure
- More than 5-7 days “hard” ventilation (?)

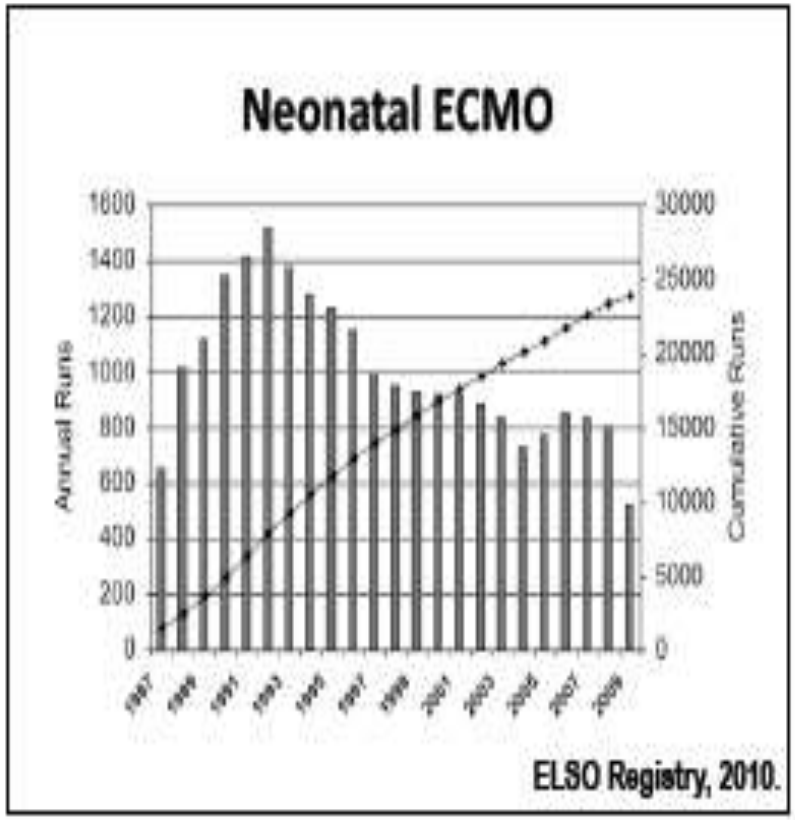
TIME and Reversibility

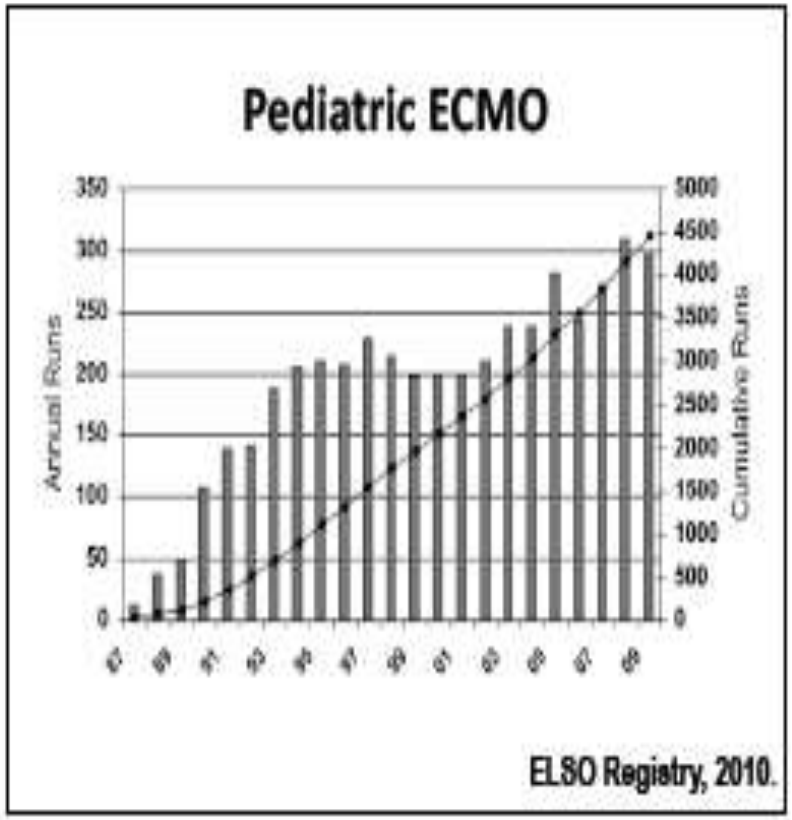


Nemours. Alfred I. duPont Hospital for Children

ELSO Registry

Trends





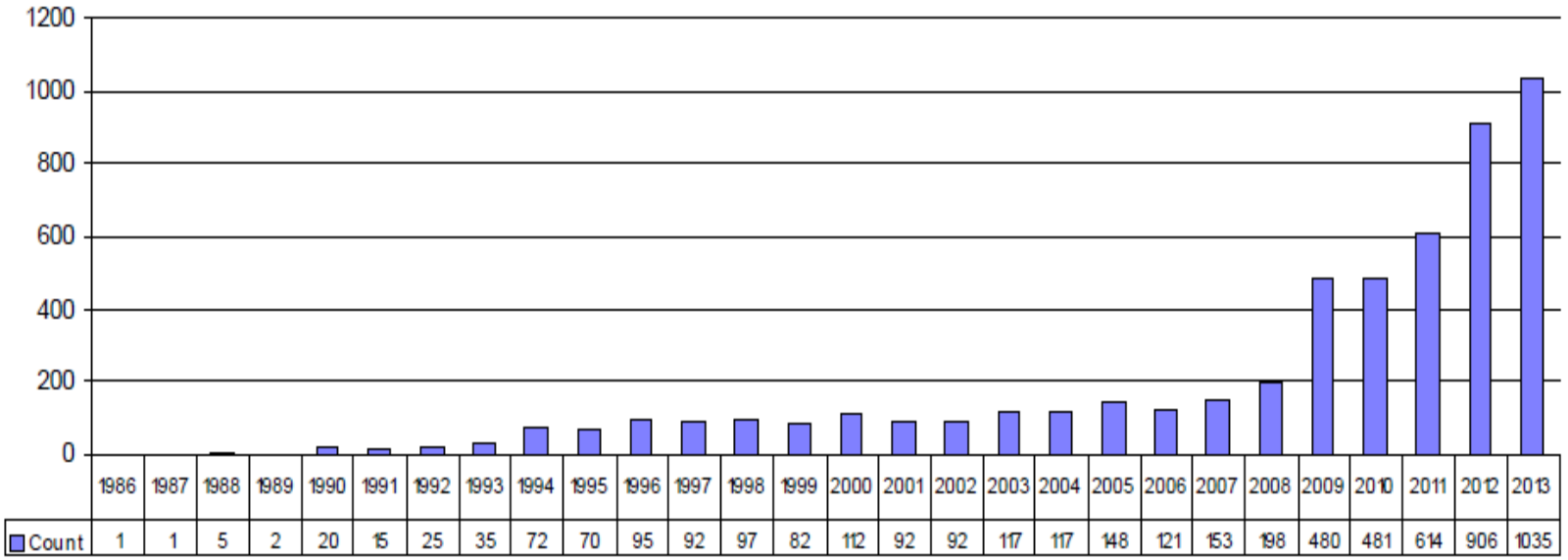
Nemours. Alfred I. duPont Hospital for Children

Adults

International Summary - January, 2014

Adult Respiratory (18 years and over)

Annual Respiratory Adult Runs



	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Count	1	1	5	2	20	15	25	35	72	70	95	92	97	82	112	92	92	117	117	148	121	153	198	480	481	614	906	1035

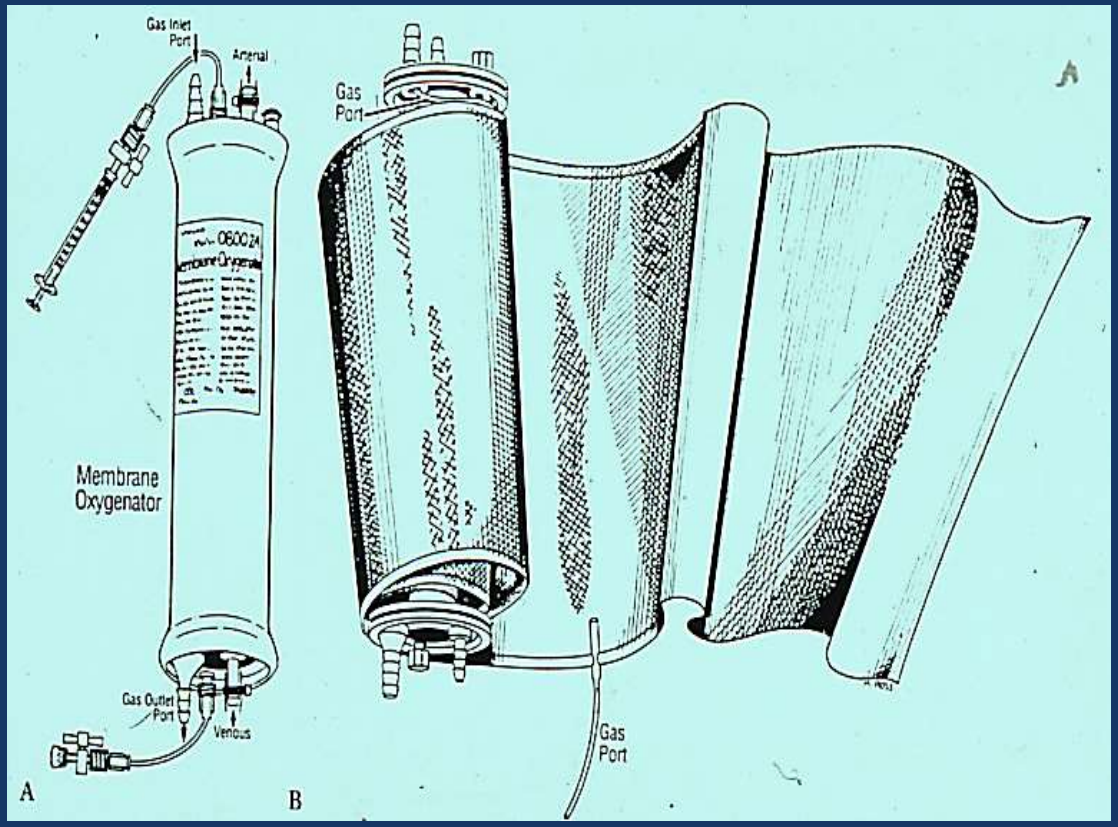
Nemours. Alfred I. duPont Hospital for Children

ECMO Equipment

Basic Components:

- Roller/Centrifugal Pump
- Oxygenator
- Blender/Gas Source
- Pressure Monitoring
- Servo Regulation
- Heater

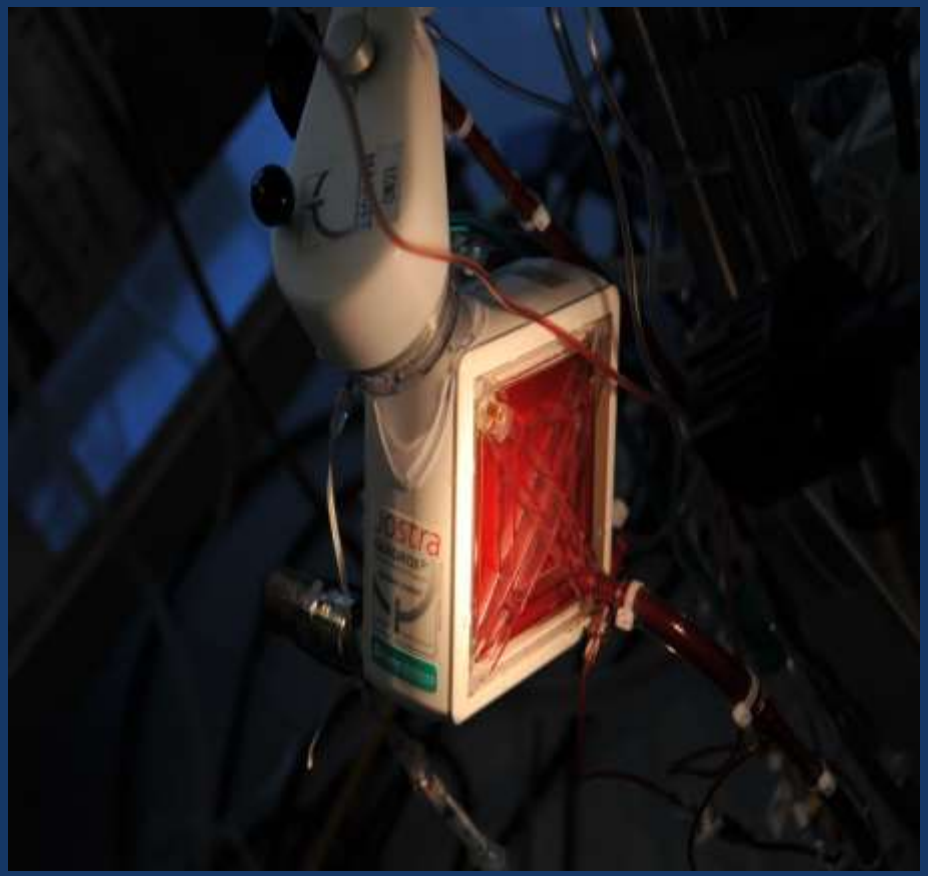
The Original ECMO Lung



Nemours. Alfred I. duPont Hospital for Children

Today's Oxygenators

- Quadrox D

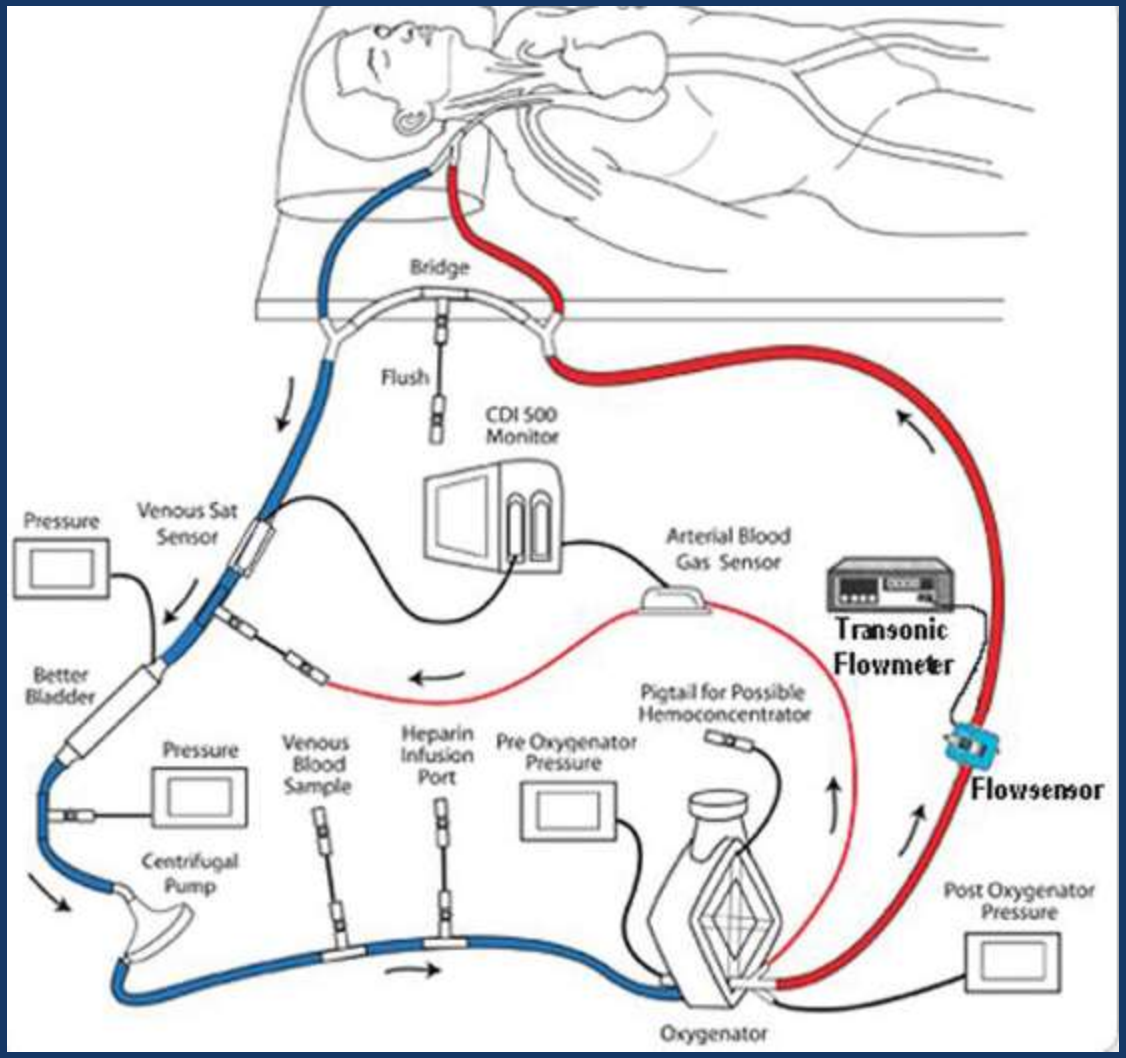


Quadrox iD Pediatric

ECMO Circuit

- Blood is drained from right atrium
- Passes through roller pump or centrifugal head
- Pumped through oxygenator
- Sweep gas flows countercurrent through oxygenator
- Oxygenated blood rewarmed
- Returned to patient via arterial cannula

ECMO Circuit



Nemours. Alfred I. duPont Hospital for Children

INDICATIONS FOR TREATMENT

Pulmonary Support

- **Neonatal:**
  - CDH
  - MAS
  - Sepsis
- **Pediatric/Adults:**
  - Pneumonia
  - ARDS
  - Bridge to transplant

Pulmonary Hypertension

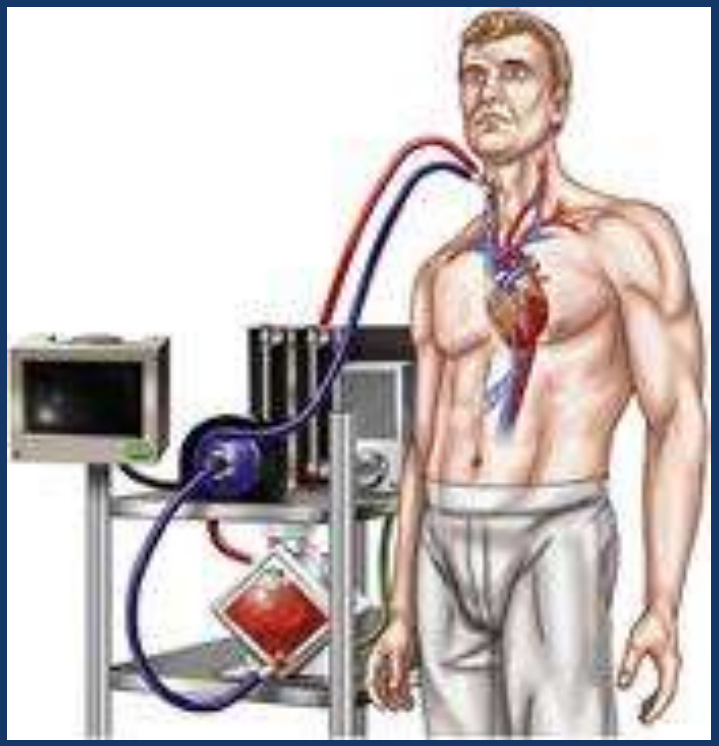
Pre-ECMO Pulmonary Management

- **High-frequency ventilation/Jet Ventilation**
  - Neonates/pediatrics
- **Low volume ventilation**
- **Nitric oxide**
- **Surfactant replacement**
- **Permissive hypercapnia**
- **Prone position**

Pulmonary ECMO Management

- **Time: Lung rest**
- **Treat underlying causes**
- **Facilitate recovery**
  - Bronchoscopy, Pulmonary Toilet
  - Surfactant, Nitric Oxide, Sildenafil, Flolan
  - Lung conditioning
  - Steroids
- **Wean from ECMO when patient can be supported on low-moderate vent settings**

Rehabilitation on ECMO – What?



Cardiac Support

- Failure to wean from CPB
- Acute deterioration (cardiac arrest)
- Low cardiac output syndrome
- Pre-op Stabilization
- Bridge to transplant or VAD

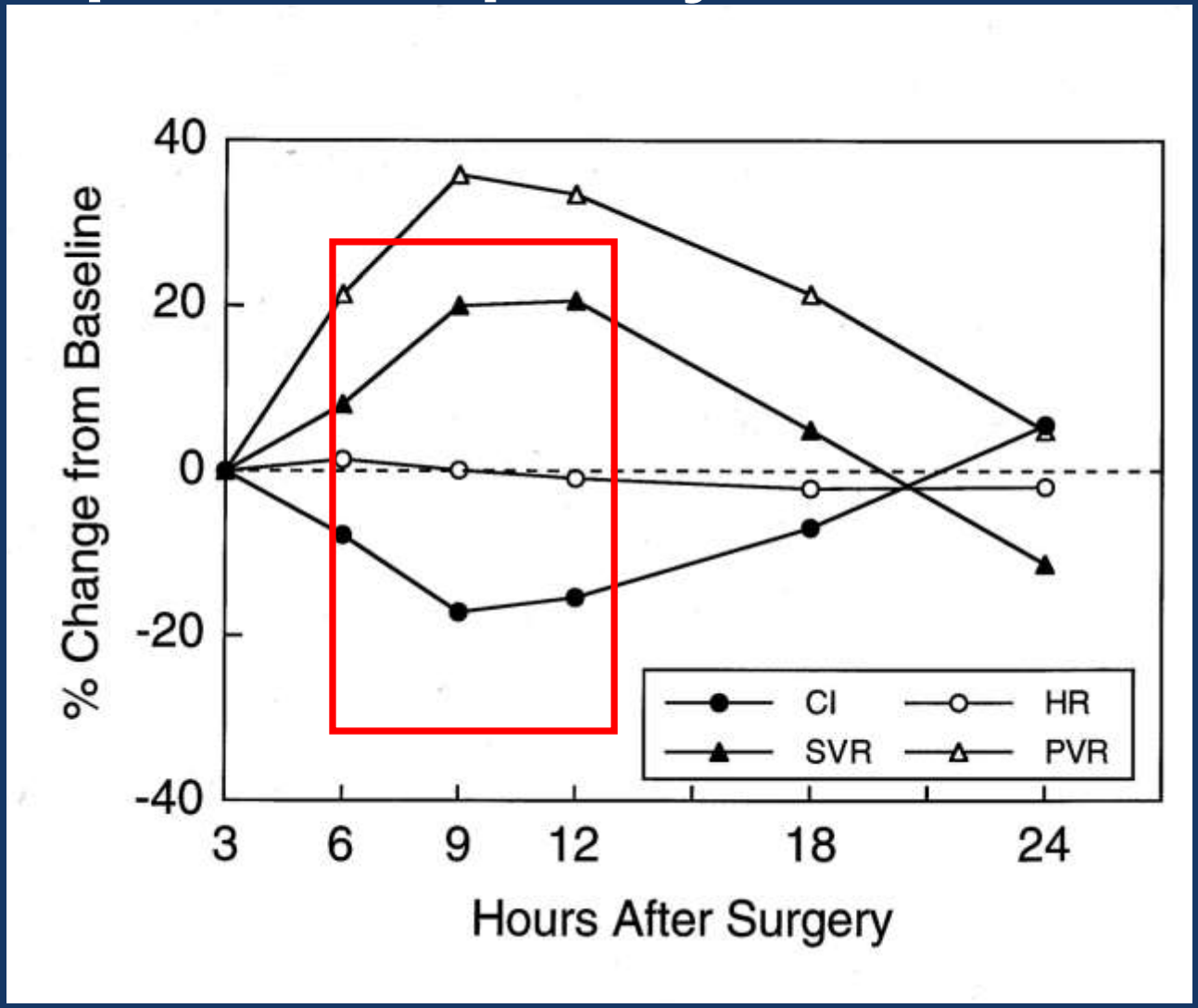
Failure to Wean From CPB

- **Poor LV function**
- **Pulmonary**
  - Pulmonary hypertension
- **Factors**
  - Preoperative condition
  - Duration of cardiopulmonary bypass
  - Hemorrhage

Low Output Syndrome

- **Predicable fall in cardiac output**
- **Most cases present 6-12 hours post-operatively**
- **Causes include:**
  - underlying CHD
  - ischemia-reperfusion injury
  - inflammatory mediator release
  - changes in LV loading conditions

Post-op Low Output Syndrome



Nemours. Alfred I. duPont Hospital for Children

Wernovsky et al, Circulation 1995

Cardiac Arrest

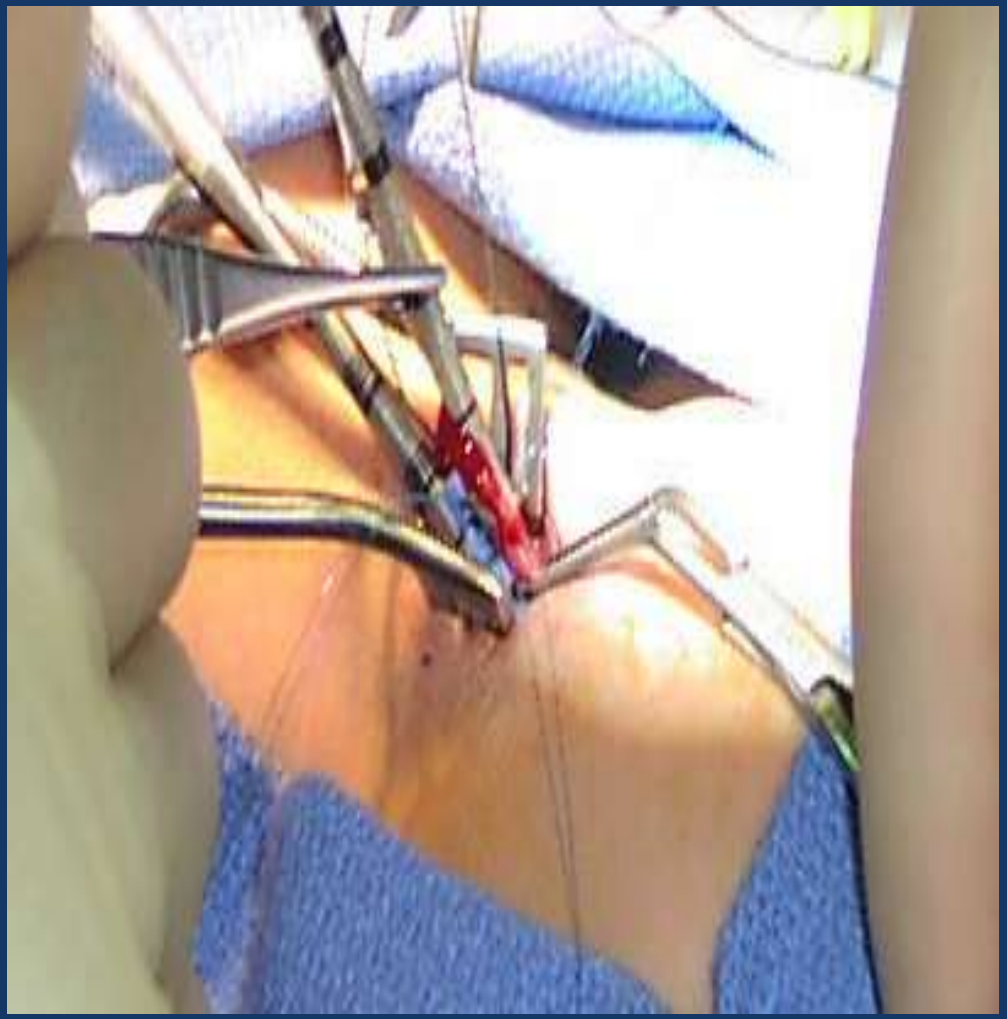
- Arrhythmia
- Tamponade / mass effect
- Loss of pulmonary blood flow
- Poor coronary artery perfusion

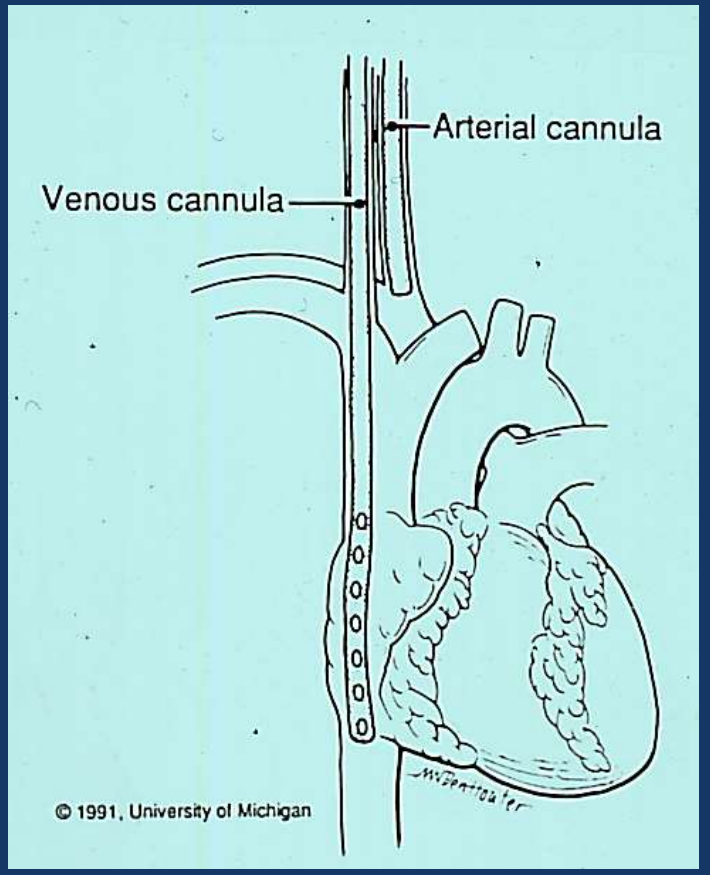
Type of Support

- **Veno-Arterial:**
  - cardiac and pulmonary support
  - cannulation of venous and arterial system

- **Veno-Venous:**
  - No cardiac support
  - Venous cannulation only
  - Improves oxygenation of pulmonary vascular bed (pphn)

VA ECMO Neck Cannulation

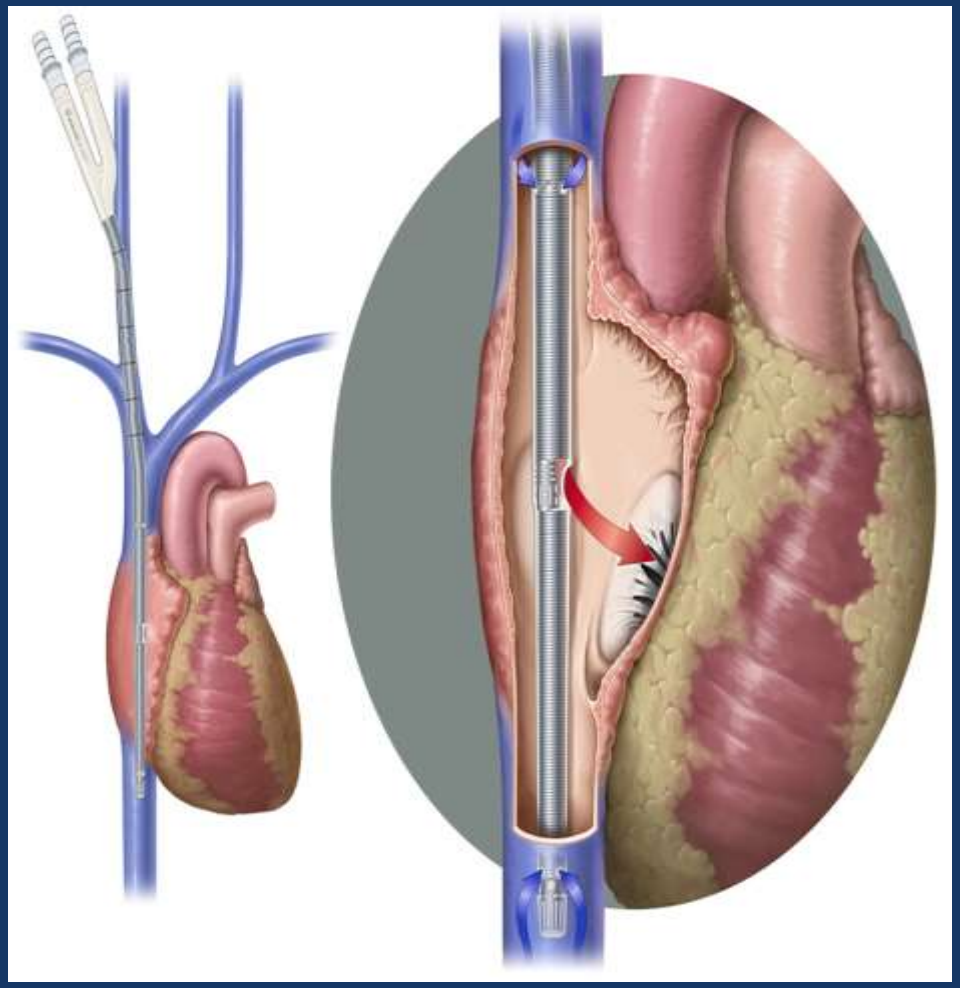


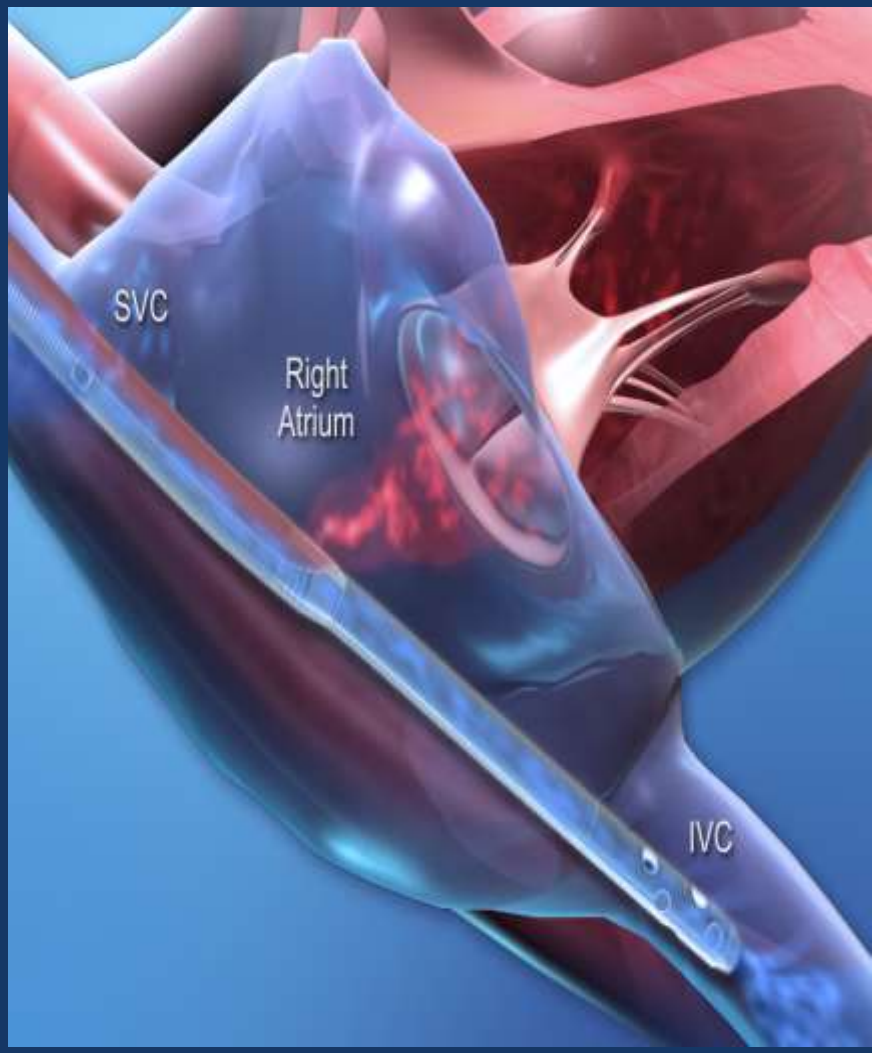


VA ECMO Chest Cannulation

VA ECMO Femoral Cannulation

VVDL Avalon Catheter





Nemours. Alfred I. duPont Hospital for Children

Nemours. Alfred I. duPont Hospital for Children

VV ECMO
Multiple Cannulation Sites

Nemours. Alfred I. duPont Hospital for Children

Patient Management

- **Multidisciplinary Team Approach**
  - Surgeons
  - Physicians
  - Nurses
  - Respiratory Therapists
  - Perfusionists
  - ECMO Specialists
  - Ancillary Staff
  - Therapeutic Services
  - Social Work

Communication

- **Communication is key**
  - Ultimately, what we do individually or as a team has a direct impact on patient outcomes.
  - Multidisciplinary
  - ECMO Rounds
    - Establish parameters
    - Develop short/long term plans

Care Models

- **Single Caregiver Model**
  - 1 Nurse assuming both roles
  - “Set it and forget it” mentality
  - In-house perfusionist to manage troubleshooting
  - Often times used with centrifugal technology
- **2:1 (ELSO recommendation & Nemours model)**
  - 1 Nurse &1 ECMO Specialist :patient
  - ECMO Specialist will manage troubleshooting of pump
  - Nurse will assume direct patient care
  - Back-up perfusionist/coordinator available for mergency management.

Anticoagulation

- Heparin bolus administered during cannulation
- Heparin infusion while on ECMO
- Anti Xa, ATIII, PTT and ACT utilized to manage heparin dose
- Activated Clotting time (ACT) monitored hourly initially and then q 2 to 4 hours once Anti Xa stable
- Must always look at full coagulation panel including Platelets, PT, INR, Fibrinogen, Calcium and TEG's.

Respiratory Assessment

- Auscultation : “I don’t hear a thing?”
- Assessment of secretions
- Daily chest x-ray
- Arterial blood gases q2-6 hours
- Continuous mixed venous, arterial saturation monitoring

Nemours. Alfred I. duPont Hospital for Children

Fluid Management

- "Capillary leak syndrome" common in first 48-72 hours
- Massive third spacing necessitates aggressive fluid replacement
- Self limiting process
- Delays pulmonary recovery
- Appears fluid overloaded but intravascularly dry

Serial X-rays during run

Pre-ECMO

Post-cannulation

16 hours into run

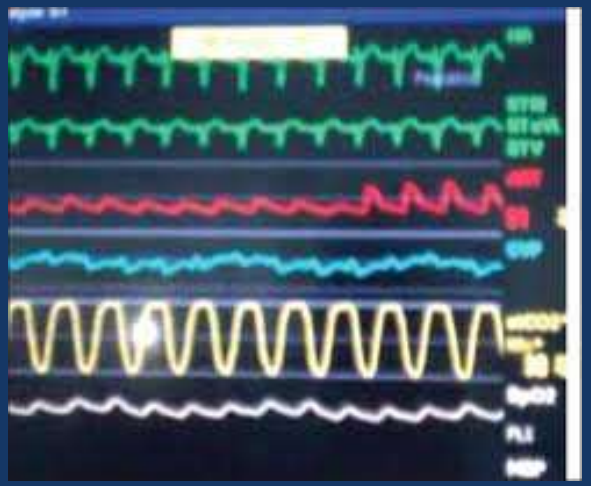
Nemours. Alfred I. duPont Hospital for Children

Neurologic Assessment

- **Neonates:**
  - Daily head ultrasound, fontanel, pupils
  - EEG if needed
  - CT if needed
- **Pediatric/Adults:**
  - LOC, pupils, GCS
  - EEG, CT if complications suspected

Cardiac Support

- Inotropes weaned once stable
- May be required throughout ECMO course
- Monitor electrolytes and rythym
- Assess pulse pressure
- Echocardiography on low flow

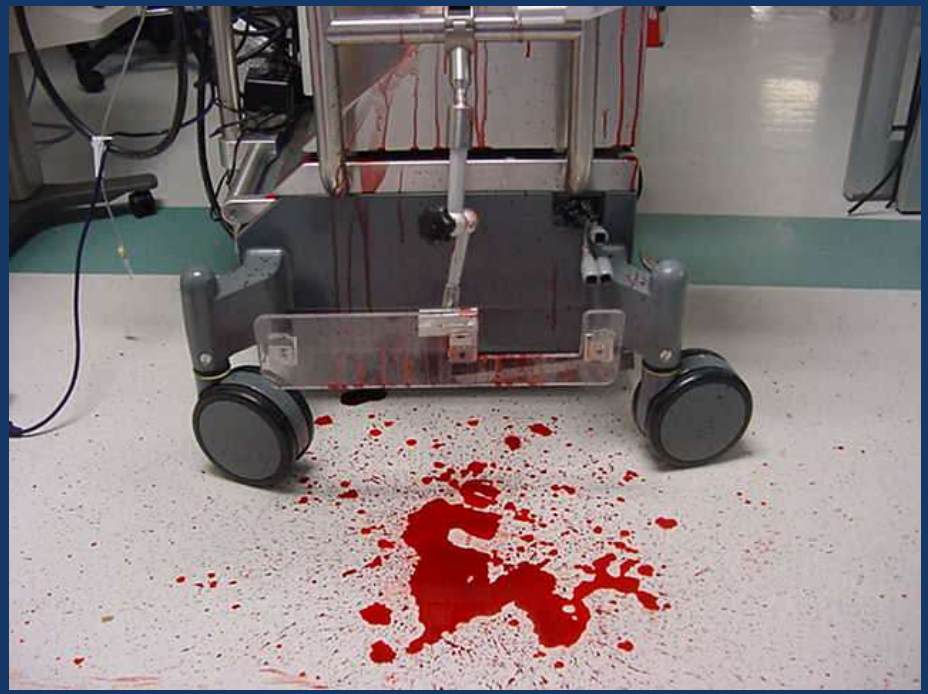


Medical Complications

- **Hemorrhage/Bleeding**
  - Surgical site
- **Fluid Overload**
  - Hemofiltration required
- **CNS**
  - Seizures, Hemorrhage, infarcts
- **Renal Failure**
  - Non-pulsatile flow
- **Sepsis**

Mechanical Complications

- Oxygenator failure
- Tubing rupture
- Air in circuit
- Pump malfunction



Future Applications

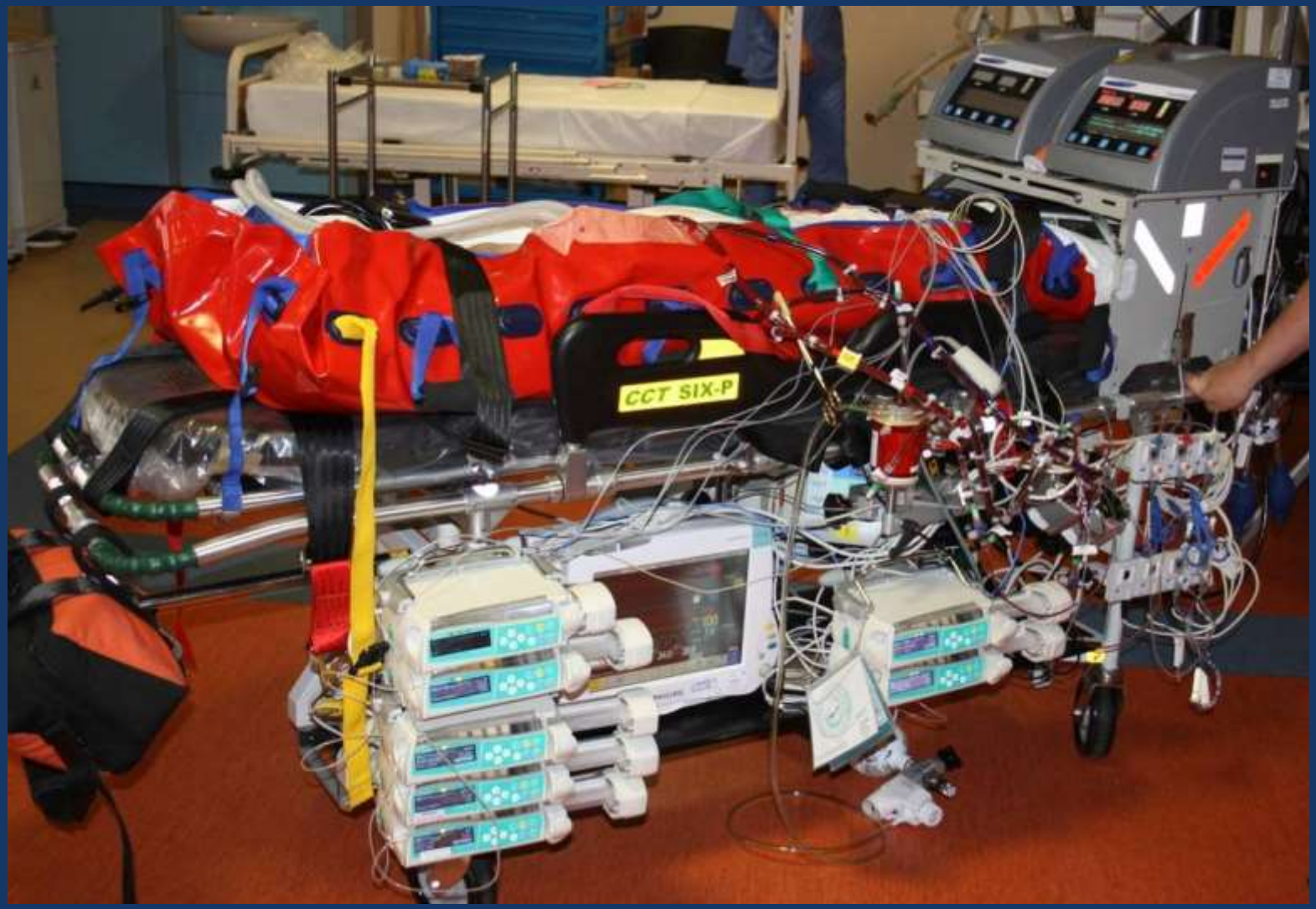
- **Smaller circuits**
- **Heparin-bonded circuits/Coated Circuits**
  - reduced need for anticoagulation
- **Increased use in resuscitation (ECPR)**
- **Inter-hospital transport on ECMO**
- **EXIT to ECMO**

Nemours. Alfred I. duPont Hospital for Children

Hanuola ECMO Transport Sled

Nemours. Alfred I. duPont Hospital for Children

ECLS Transport



Ex Utero Intrapartum Therapy (EXIT)

Thank You!