

Extracorporeal support: Overview of Different Modalities to Support Heart Failure in Children

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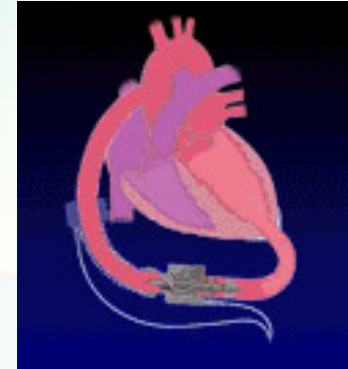






Outline

- Overview
- Heart failure in children
- ECLS
 - VA ECMO
 - Ventricular Assist Devices in children
- Future directions



Heart failure in children

- “A person has heart failure when his heart is unable to pump enough blood around to supply the oxygen the body needs”. World Health Organization
- “For a child to grow and develop, the heart needs to maintain normal pump function, to provide optimal blood flow throughout the body”.
American Heart Association
- 2 types
 - Over-circulation failure 1% of newborn
 - Pump failure (infection, valve defect, arrhythmias, drugs...)
- Signs and symptoms
 - Non-specific



Nomenclature

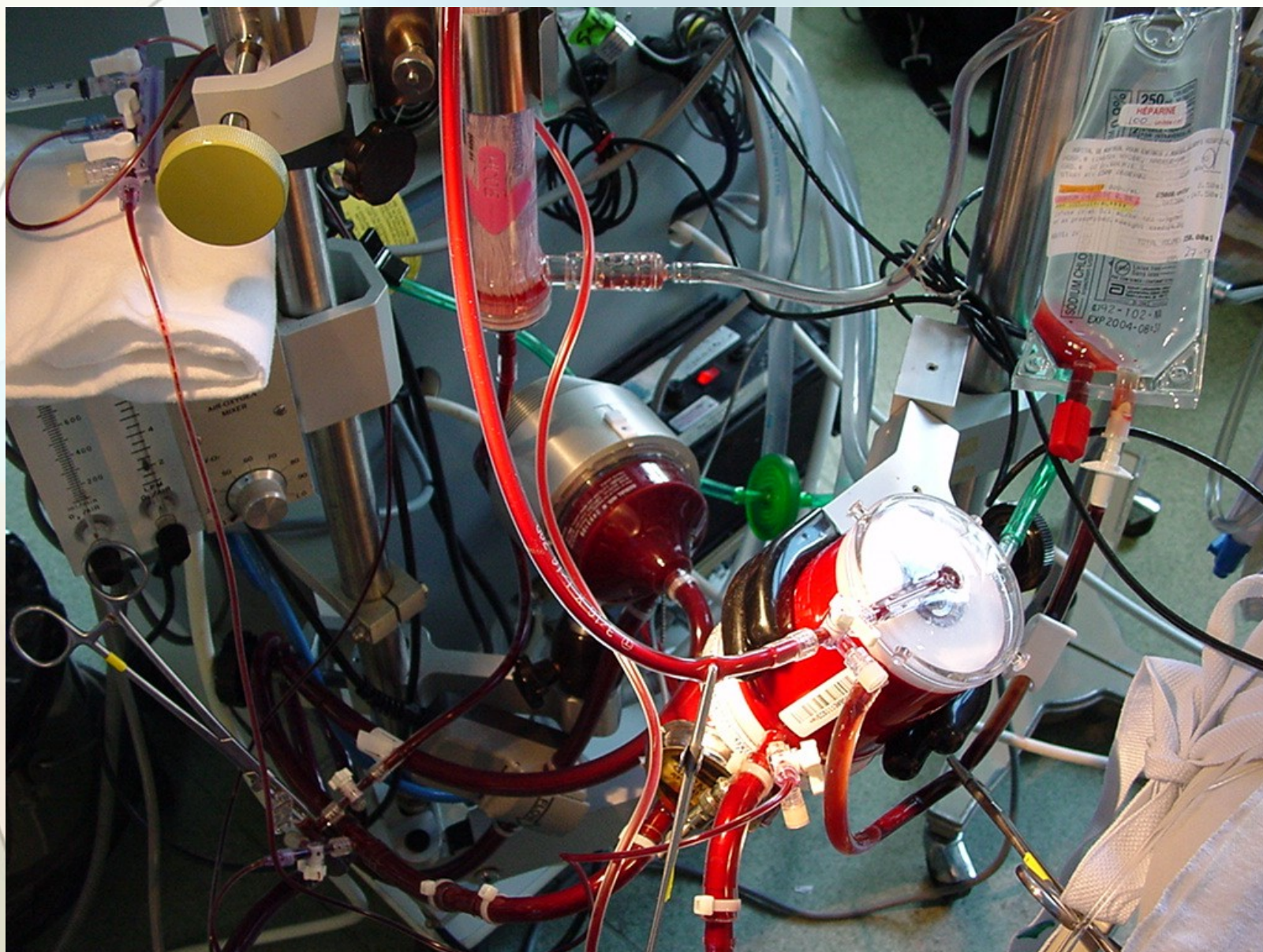
- Extracorporeal support (ECLS)
 1. Extracorporeal Membrane Oxygenation (ECMO)
 - Veno-venous VV
 - Veno-arterial VA
 2. Ventricular Assist Devices (VAD)
 3. Cardiopulmonary Bypass (CPB)



Extracorporeal Life Support (ECLS)

- **Offered to patients that are likely to die from the primary disease despite optimal conventional therapy**
- No specific criteria
- Survival rate of ECMO from ELSO registry (JAN 07)
 - Neonatal respiratory failure 76%
 - Pediatric respiratory failure 56%
 - Adult respiratory failure 51%
 - Neonatal cardiac failure 38%
 - Pediatric cardiac failure 44%
 - Adult cardiac failure 32%





VA ECMO - Indications

- Inability to maintain cardiac output despite maximal inotropic support
- As a bridge to recovery
- As a bridge to cardiac transplantation
- Heart failure from various causes
 - Post-operative complications of a repair of congenital heart defect
 - Unable to wean from Cardiopulmonary Bypass (CPB)
 - Low Cardiac Output Syndrome (LCOS)
 - Cardiomyopathy - Myocarditis - Arrhythmias
- ECPR – Extracorporeal Cardiopulmonary Resuscitation

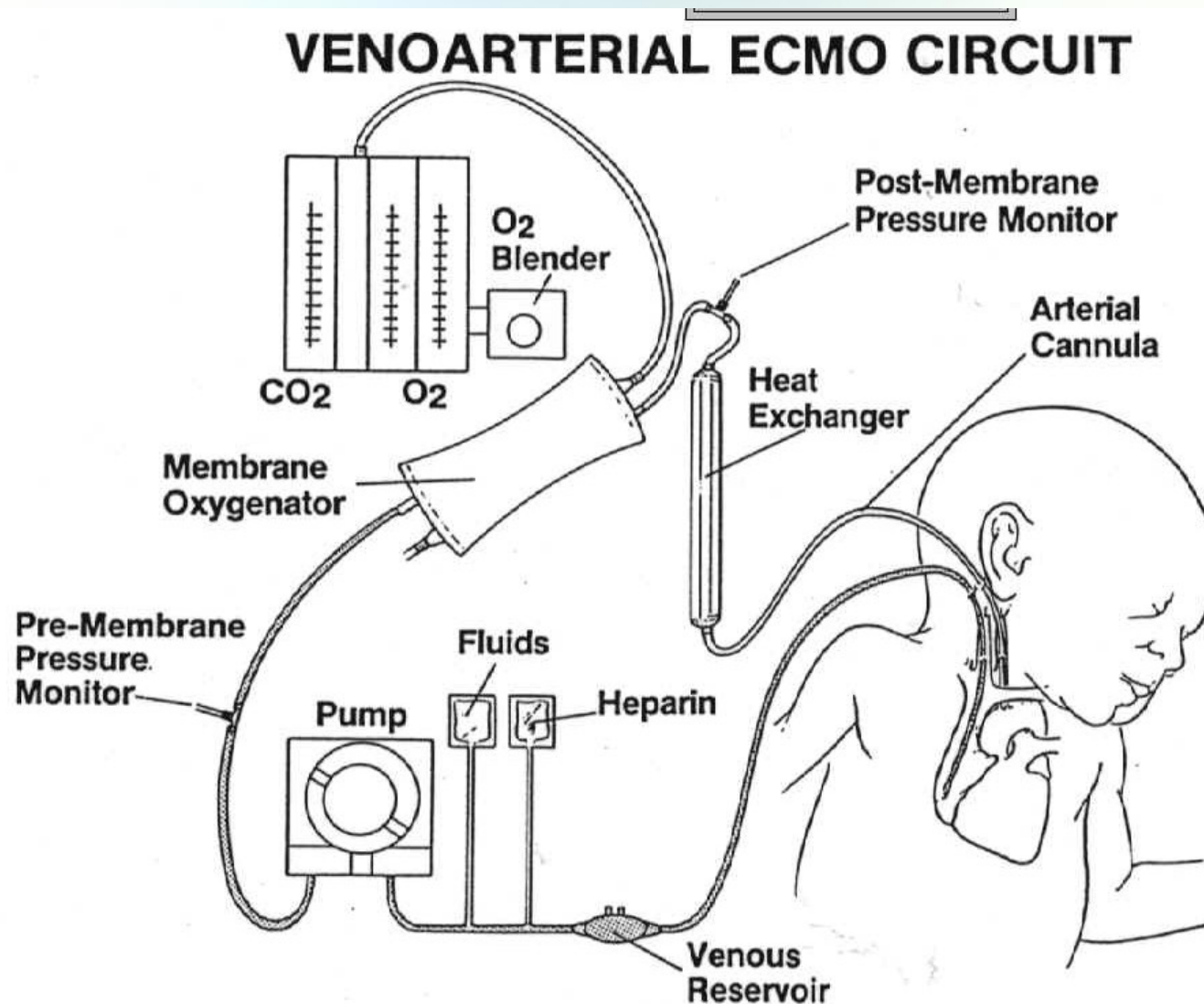
Contraindications

- End-stage irreversible and inoperable disease
- Significant neurologic impairment
- MultiSystem Organ Failure (MSOF)
- Uncontrolled bleeding
- Limited vascular access

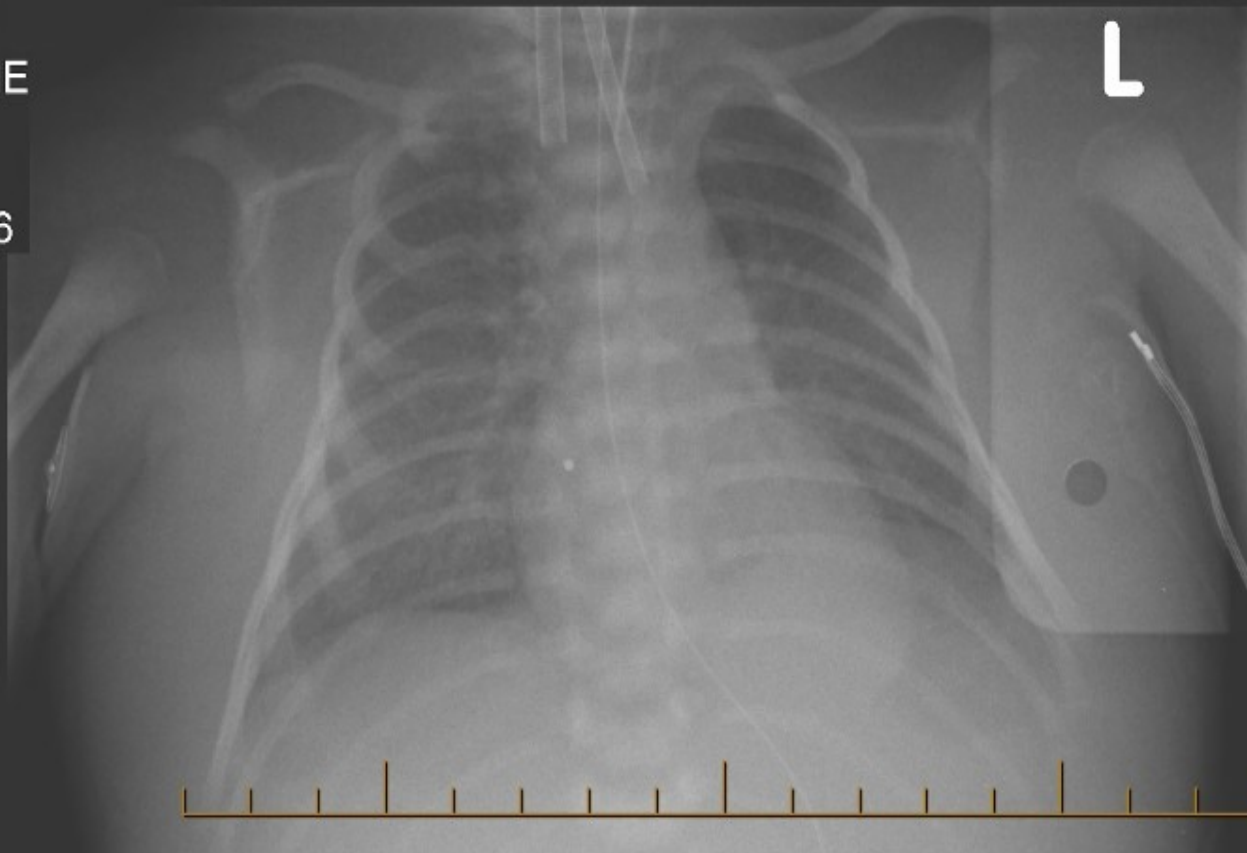
***RELATIVE

It remains a case by case discussion among the ECMO team

VA circuit



AP SUPINE
5 76
6H00
18 NOV 06



2370x1770
Zoom: 38 %
Compression: 75:1
W: 1140 L: 688



VA ECMO

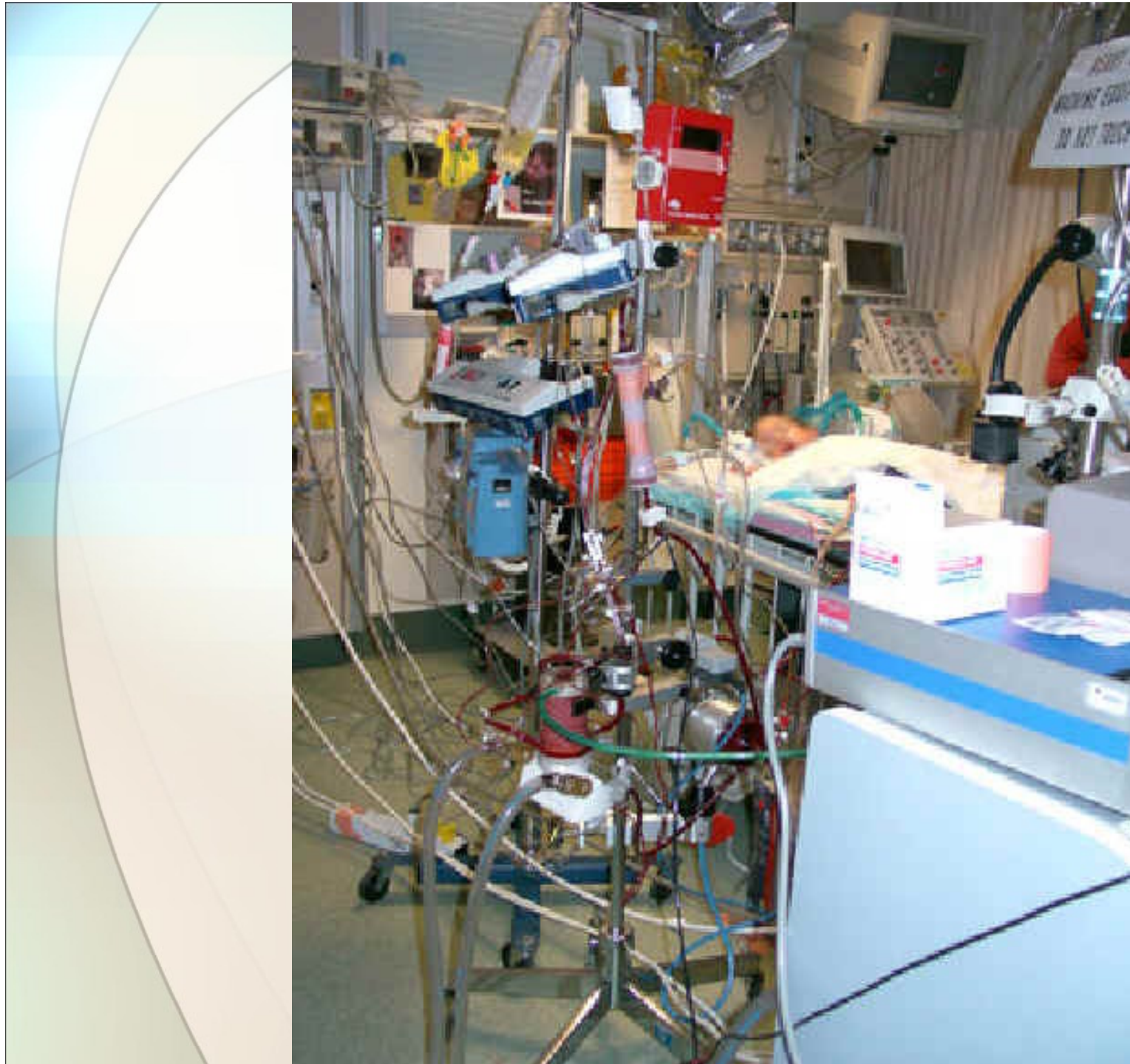
- Different than CPB
 - Venous drainage is limited to the amount of flow needed
- Circuit blood flow = 30-80 % of cardiac output
- Maximize O₂ delivery
 - Optimal hematocrit
 - Fully saturated hemoglobin
- Allow for decreased ventilatory support
 - Lung-protective ventilatory strategy
- Allow for weaning of inotropes and vasopressors
- Decompression of left atrium
- Diuresis may be supported by the system



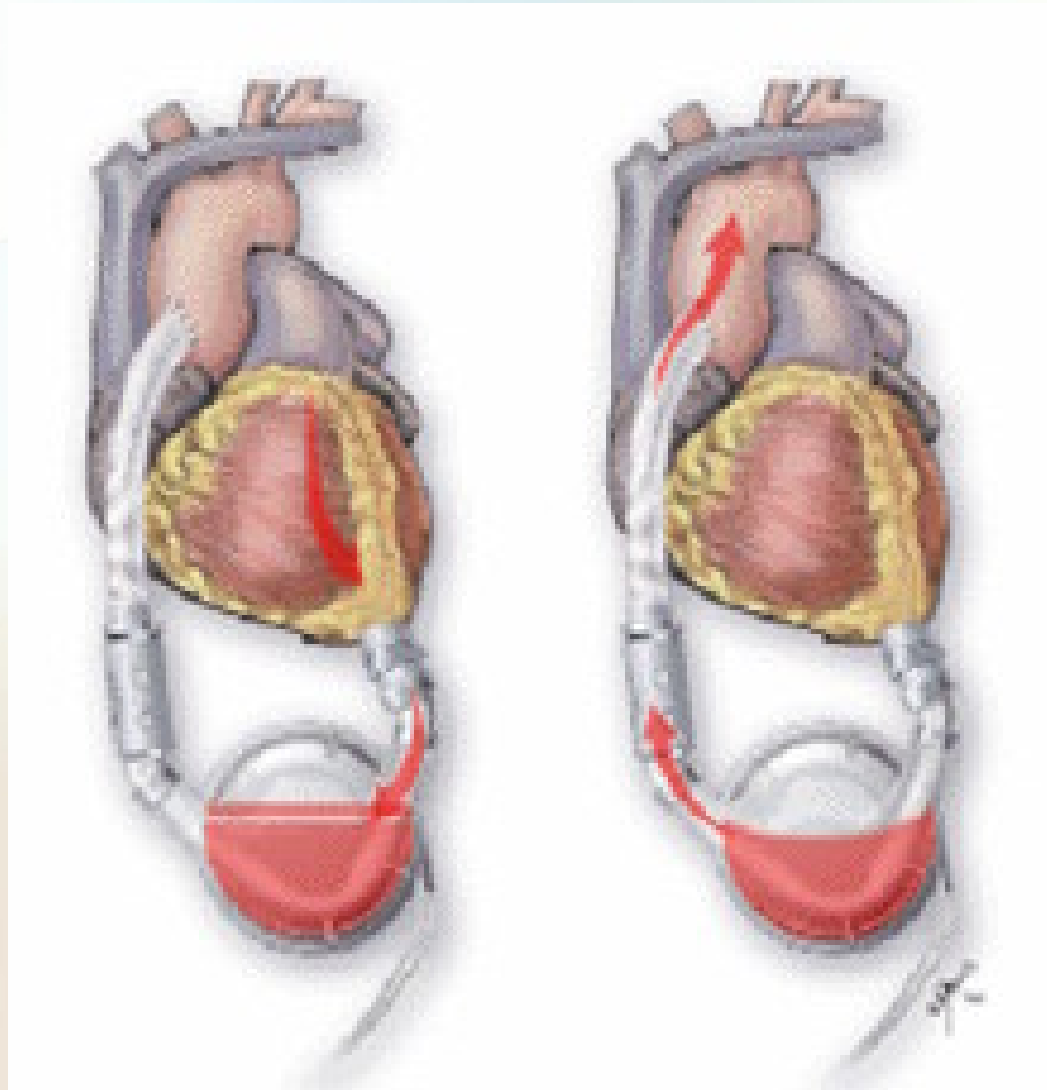
Disadvantages and complications

- Ligation of carotid artery
- Decreased oxygenation to coronaries
- Risks of air or clot embolization
- Risks of bleeding
- Duration of ECMO depends on
 - Recovery
 - Transplantation
 - Related complications





Ventricular Assist Devices (VAD)



Ventricular Assist Devices (VAD)

- 2 different types

• Pulsatile

- Physiological
- Examples in pediatrics
 - Berlin heart
 - Thoratec

• Non-pulsatile

- Less physiological
- Smaller in size – smaller pt
- No valves
- Less expensive – more durable
- Examples in pediatrics
 - Micromed DeBakey
 - Jarvik 2000 IVAS

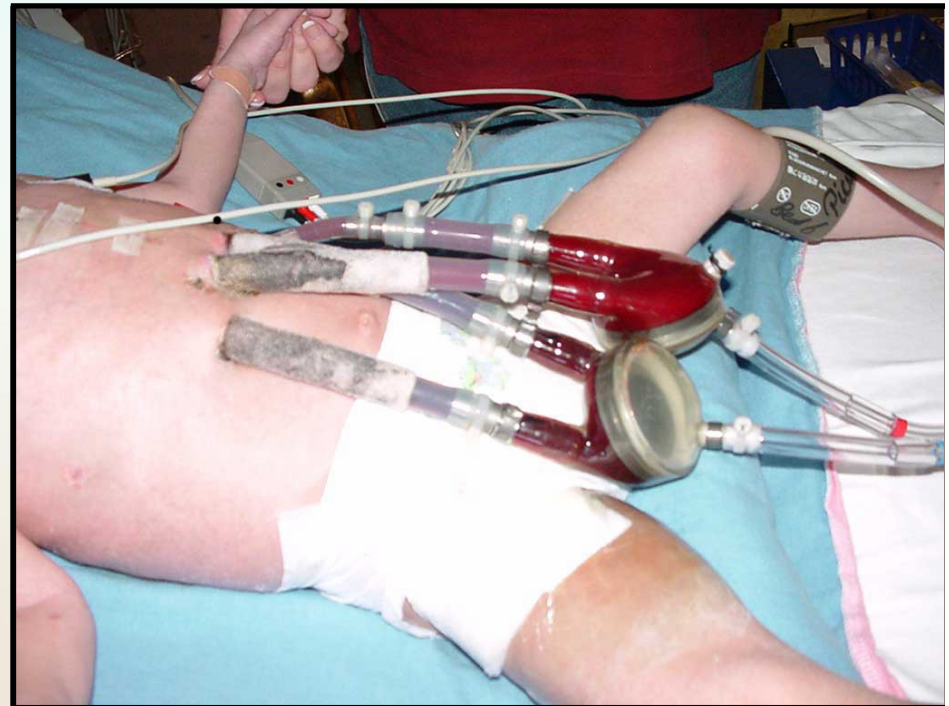
Ventricular Assist Devices in children

- Berlin heart
 - PULSATILE
 - Pneumatically driven blood pump
 - Univentricular or biventricular
- To maintain the cardiovascular system and improve the pt's condition
 - Bridge to transplantation
 - Bridge to recovery



The Berlin heart

- Blood pumps
 - Membrane separates blood from air
- 4 cannulas (titanium)
 - Atria
 - Great arteries
- Valves (unidirectional flow)
- Driving unit
- Different sizes



Management of the Berlin heart

- Assessment of cardiac output $CO = HR \times SV$
 - Preload (filling of the pumps)
 - Afterload (signs of perfusion)
 - Contractility (external pumps!!!)
 - ECG \neq pulse
 - Pump rate (and pulse) depends on the machine!
- Anticoagulation
- By the perfusionist!



Risks and complications

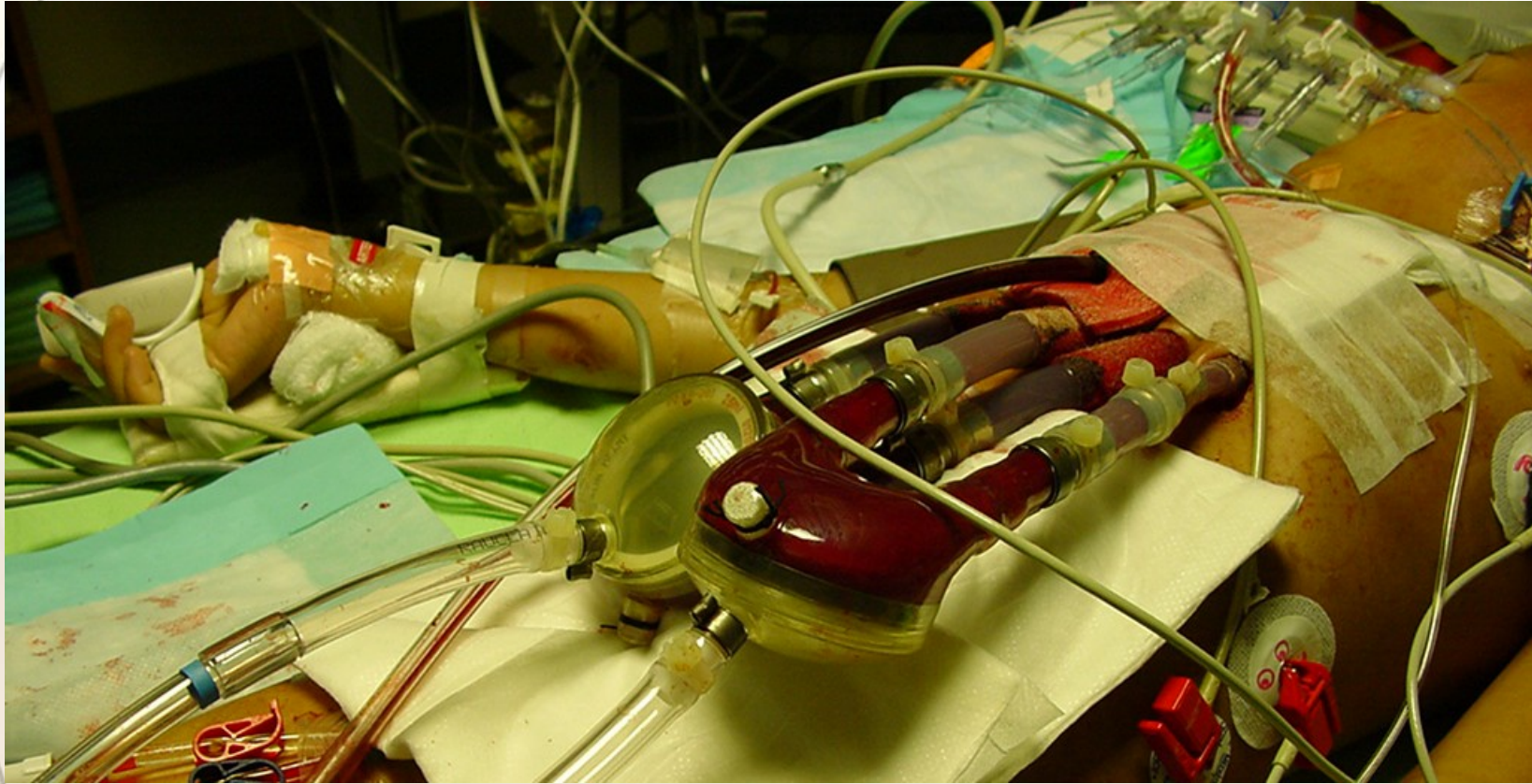
- Bleeding
- Infections
- Clots or fibrin deposits in cannulas or pumps
- Insufficient cardiac output - LCOS
- Duration
 - Recovery
 - Transplantation
 - Complications



Limited experience

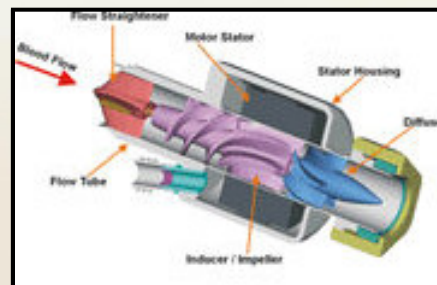
- Well recognized VAD
 - > 226 children 1990-2006
- Very limited neonatal experience worldwide
 - Guarded prognosis
 - Promising device
- In Canada, still case by case decision
- 3 pediatric cases at the MCH
 - 2002 – youngest in North-America 26 mo
 - 33% survival
 - No neonatal experience
- 4 centres in Canada





Micromed DeBakey

- Axial pump – NON-PULSATILE
- Developed in cooperation with the NASA
- FDA approved in the USA
- Age 5 to 16 yo
- BSA $> 0.7\text{m}^2$



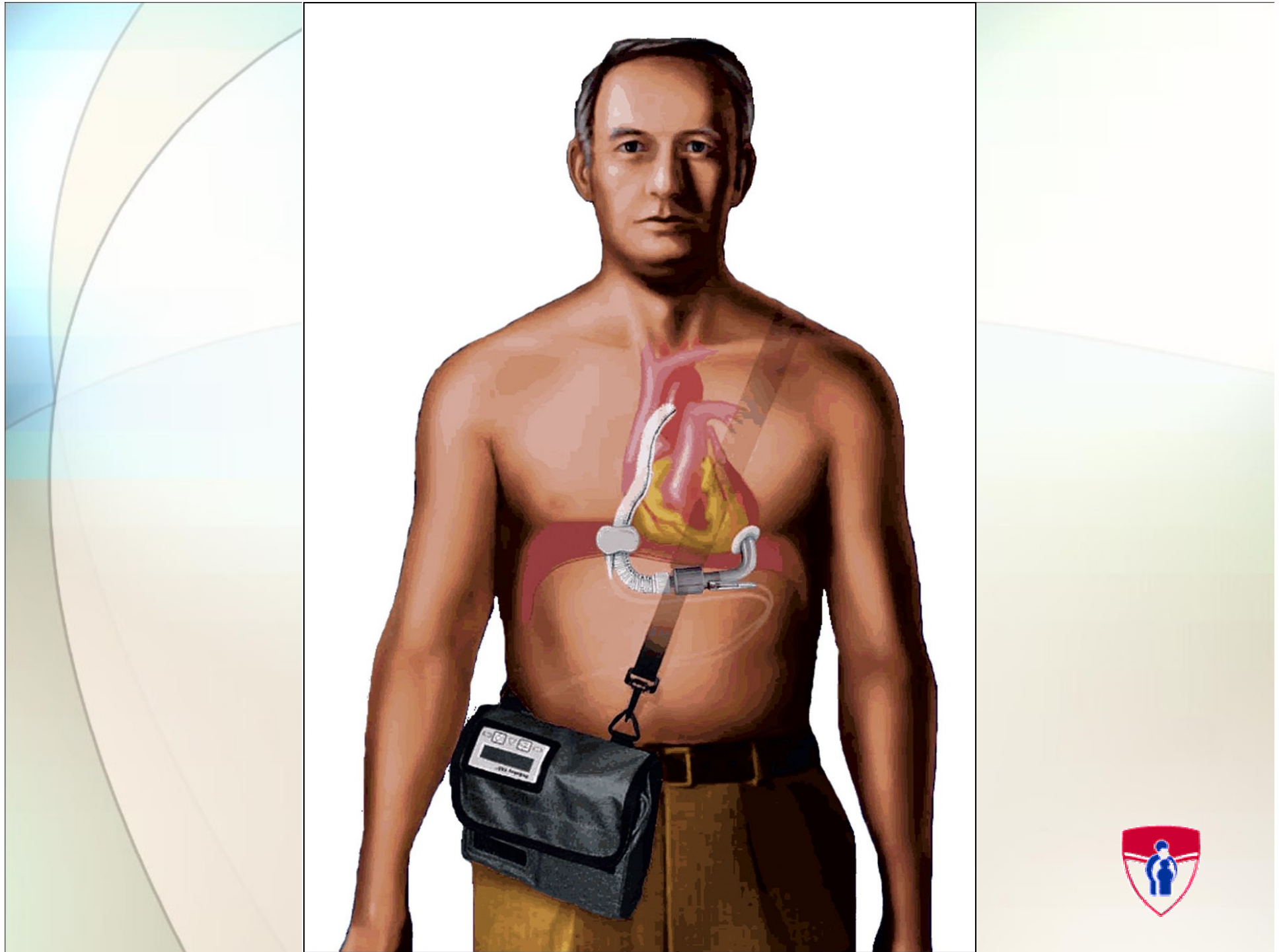
Micromed DeBakey

Advantages

- Small size and light weight
- Low infection rates
- Easy to implant
- Blood flow probe
- Children device available
- Silent compared to others
- Mobility + QOL

Disadvantages

- Pediatric use limited to 5-16 years of age
- Non-pulsatile
- No experience in Canada



Future directions

- Research and development of VAD for infants and neonates
- Promotion of organ donation
- Accessibility of devices in different part of the world
- IABP in children? ♥
- Destination therapy: Mechanical heart? ♥



Intra-aortic balloon pump

- Therapy well used in adult
 - Developed in children 1989
- Principles
 - Balloon placed in descending aorta filled with helium
 - Deflated during systole
 - It creates a vacuum effect and reduces afterload
 - Inflated during diastole
 - It creates better coronary perfusion
 - Challenges to time with cardiac cycle



Advantages and disadvantages

Advantages

- Easy to install
- Simple to use
- Portable equipment
- Less invasive
- Less expensive

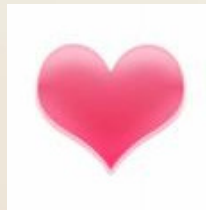
Disadvantages

- Timing of inflation and deflation is difficult
- New option in pediatric
- Learning curve



Mechanical heart

- Scarce resource : non-availability of organs
- Alternative to heart transplant
- Montreal, Dec 2006
 - 1st **HeartMate II** mechanical heart
 - Clinical trial by the manufacturer **Thoratec**
 - Long term device – 10 years
 - 65 year-old man with heart failure



Thank you!



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