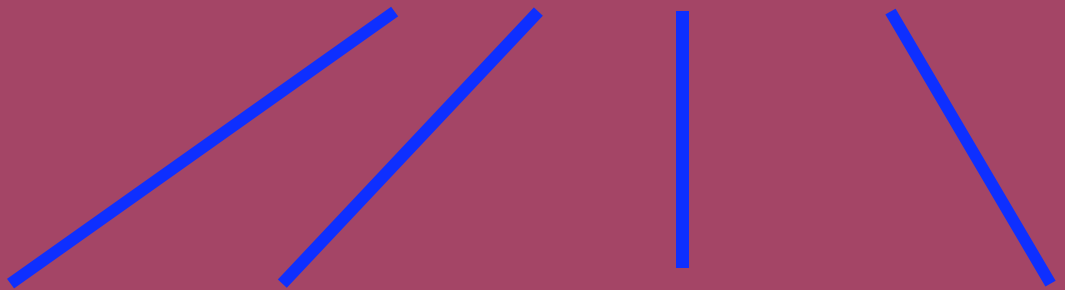
ECMO



Extra Corporeal Membrane Oxygenation

ECMO

- 1972 - first reported clinical use.
- 1976 - survival reported at 15%.
- Used when circulatory and respiratory support is needed.

Criteria:

1. Acute cardio/pulmonary disease must be reversible.
2. 80% predicted mortality with “conventional therapy”.
3. Ability to achieve “normal” quality of life following ECMO.
4. No major co-existing deficits.

Contra-indications

1. < 35 weeks gestation.
2. < 2000 grams birth weight.
3. Intra-cranial haemorrhage.
4. Severe coagulopathy.
5. > 10 days IPPV.
6. Any or all of the above criteria.

ECMO

Who might need it, and why.

Neonates:

- Respiratory distress syndrome
- Meconium aspiration
- Persistent foetal circulation
- Congenital diaphragmatic hernia
- Post cardiac surgery

ECMO

Who might need it, and why.

Infants,children, adults:

- Adult respiratory distress syndrome
- Post cardiac surgery
- Cardiomyopathy
- Bridge to transplant?

Respiratory Distress Syndrome

(also known as Hyaline Membrane Disease)

- Low or absent surfactant level

→ alveolar atelectisis

→ ↑ respiratory effort

→ ↑ atelectisis

→ pulmonary hypertension

→ ↓ pulmonary perfusion → hypoxia & hypercapnia

→ acidosis

Alveolar damage, ↑ pulmonary hypertension, right - left shunt, etc, etc...

Meconium Aspiration

- May occur *in utero* or at birth
- Varying degree of airway obstruction & irritation/inflammation
- Problems are either: - emphysema
  - atelectisis
- Airleak-pneumothorax is common
- Hypoxia/hypercarbia → acidosis → etc, etc.

Persistent Foetal Circulation

(also known as Persistent Pulmonary Hypertension of the Newborn - PPHN)

Normally at birth:

Pulmonary vascular tone decreases

Ductal tone increases → closure

Pressure differential causes the PFO to close

In PFC this does not occur.

Persistent Foetal Circulation

Causes of PFC:

Foetal pulmonary arteriolar hypertrophy

Insufficient reduction in pul. vasc. tone

Vaso-spasm or vasoconstriction due to hypoxia / acidosis

Polycythemia; hypoglycaemia; hypocalcaemia

Inflammatory response (prostaglandin/leucotriene)

Meconium aspiration, CDH

Congenital Diaphragmatic Hernia

- Lung hypoplasia → compromised pulmonary function → hypoxia/acidosis

- Surgical/medical intervention → maximise function of both lungs

ECMO

How to tell if you need it...

$$\text{Ventilation Index (VI)} = \frac{RR \times PIP \times PaCO_2}{1000}$$

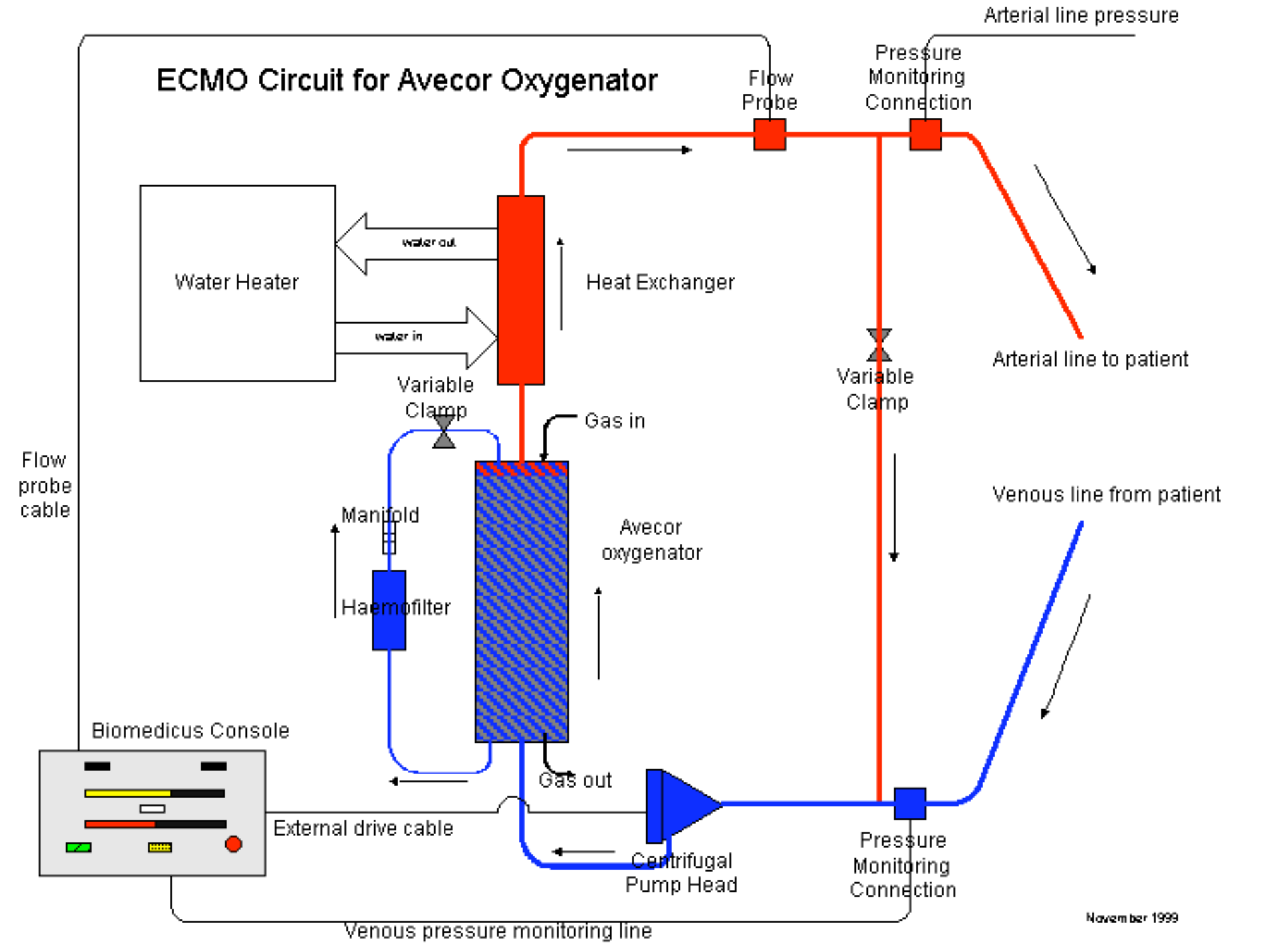
In neonates	VI > 90 for 4 hours
In C.D.H.	VI > 70 for 4 hours
In children	VI > 40 for 4 hours

ECMO

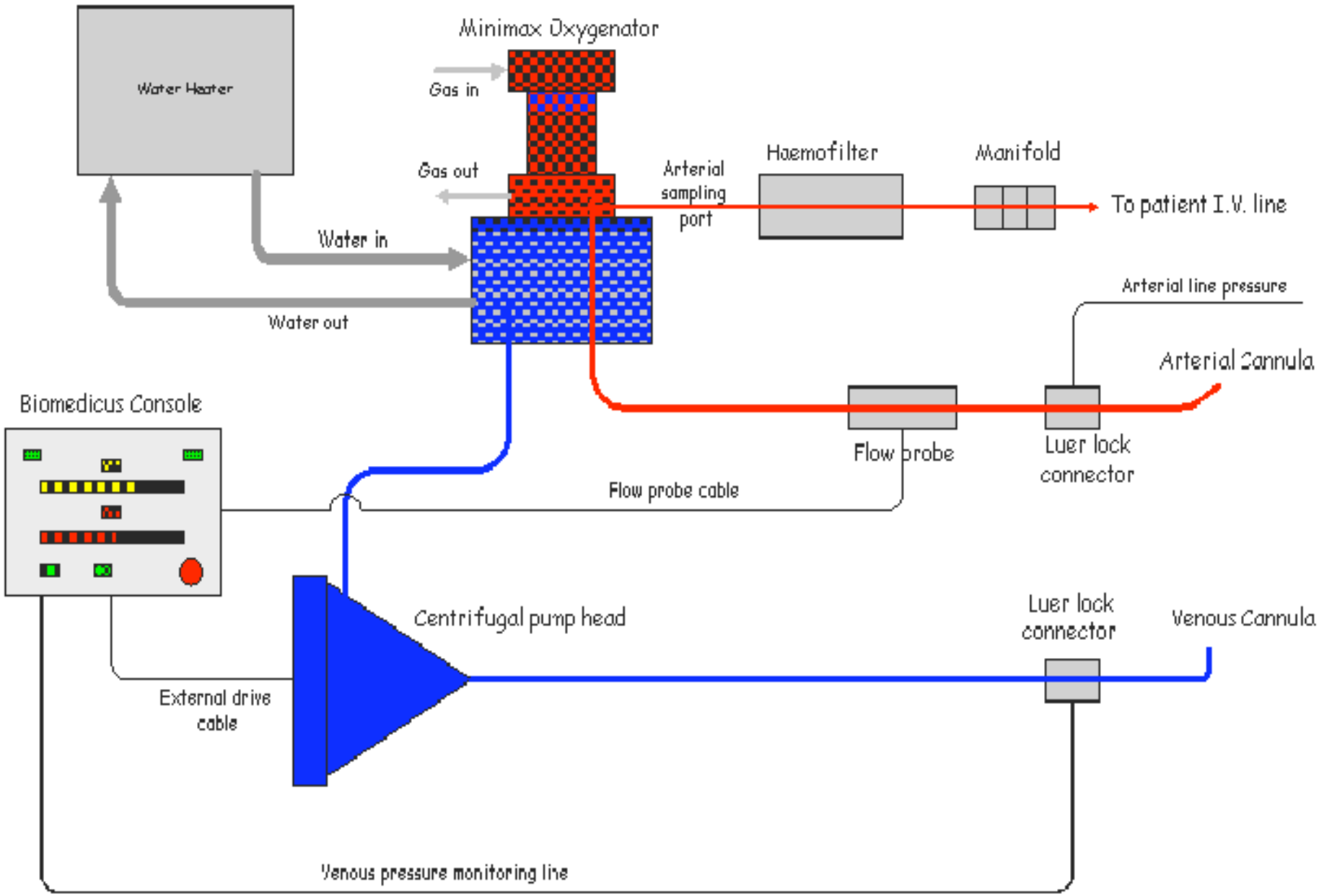
How to tell if you need it...

$$\text{Oxygenation Index (OI)} = \frac{\text{MAP} \times \text{FiO}_2}{\text{PaO}_2}$$

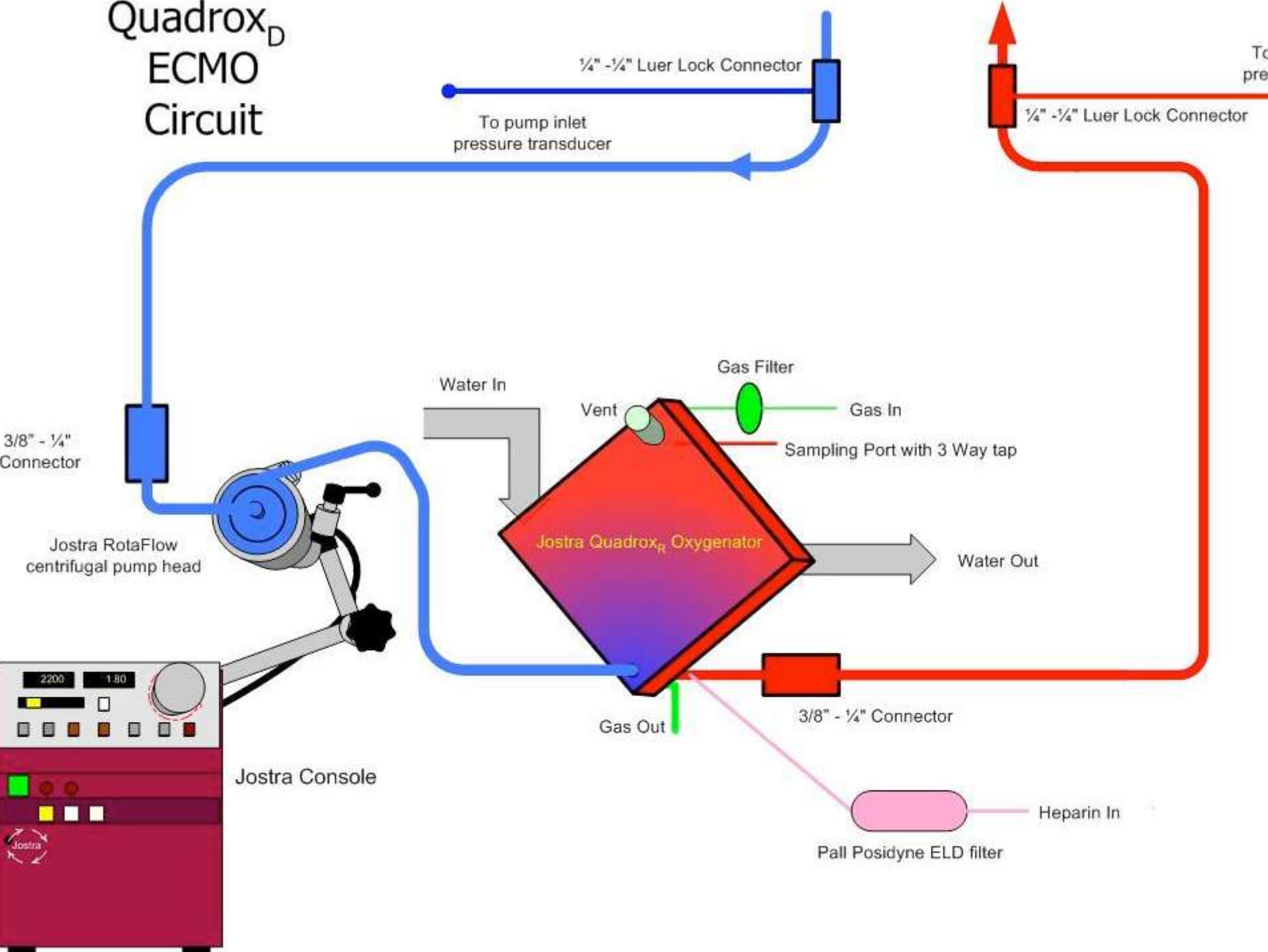
In neonates	OI > 0.40 for 4 hours
In C.D.H.	OI > 0.25 for 4 hours
In children	OI > 0.40 for 4 hours


ECMO Circuit for Avecor Oxygenator
Arterial line pressure
Flow Probe
Pressure Monitoring Connection
Water Heater
water out
water in
Heat Exchanger
Arterial line to patient
Variable Clamp
Variable Clamp
Gas in
Flow probe cable
Manifold
Haemofilter
Avecor oxygenator
Venous line from patient
Biomedicus Console
Gas out
External drive cable
Centrifugal Pump Head
Pressure Monitoring Connection
Venous pressure monitoring line
November 1999

ECMO Circuit for Minimax Oxygenator



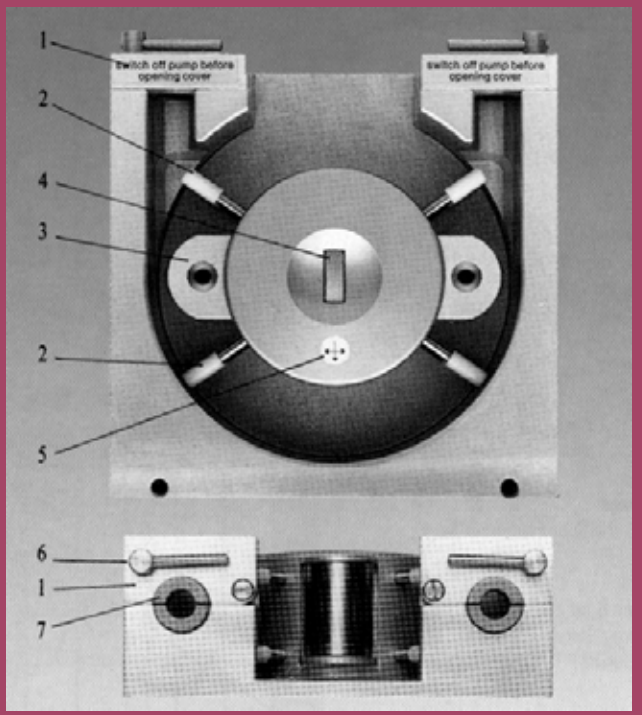
Quadrox$_D$ ECMO Circuit



Pumps

1. Occlusive roller pump

- positive displacement
- resistance independent
- not used at RCH for ECMO



Pumps

2. Constrained vortex pump

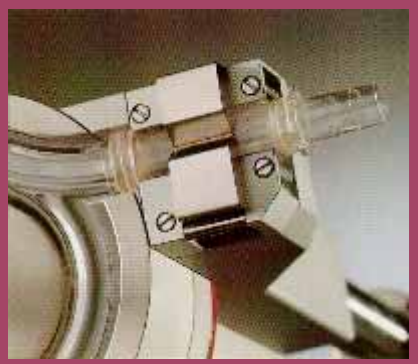
- Resistance dependent
- Centrifugally generated pressure differential
- Used exclusively at RCH for ECMO & VAD

Constrained vortex pump

- Non occlusive
- Centrifugal motion
- Flow range
- Output is - resistance dependent
  - patient volume dependent
- Revolutions per minute
- Output may vary

Constrained vortex pump

- Negative venous pressure



relates to - atrial volume status

- cannula position

- pump rpms

- “Ideal” value
- Never sample from neg. venous pressure line
- Zeroing neg. venous pressure line

Is too much ever enough ???
(…...ECMO flows)

Cardiopulmonary Bypass Flow Rates

- 150 ml/kg/min (patients < 10 kg;
  < 18 months)

- 2400 ml/m^2/min (others)

m^2 = body surface area

ECMO

Ventilator settings should be minimised

(0.21, 20/5, 10)

Clinical signs are all important !!!

Blood gases Sepsis Minimal sedation

Difference between VA & VV ECMO

ECMO Oxygenators

Avecor:

- 6 sizes
- spiral wound silicone
- “True” membrane

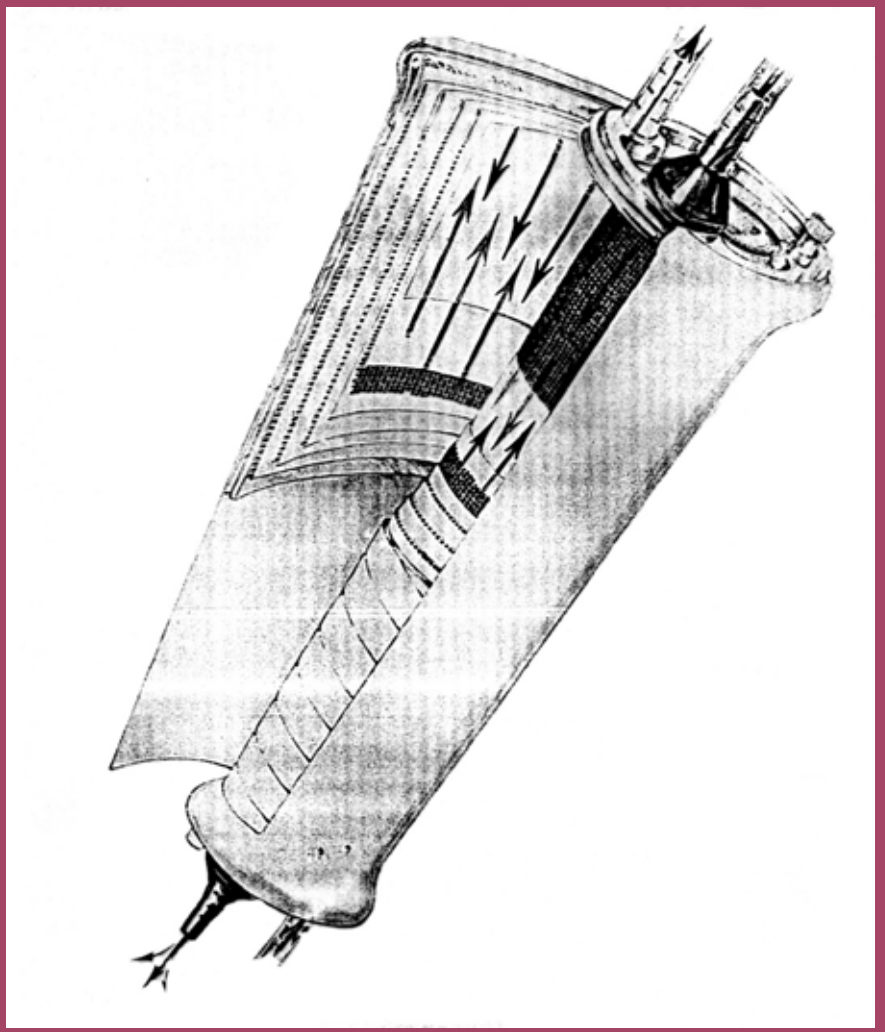
Medtronic:

- 2 sizes
- Polypropylene hollow fibres
- “Pseudo” membrane

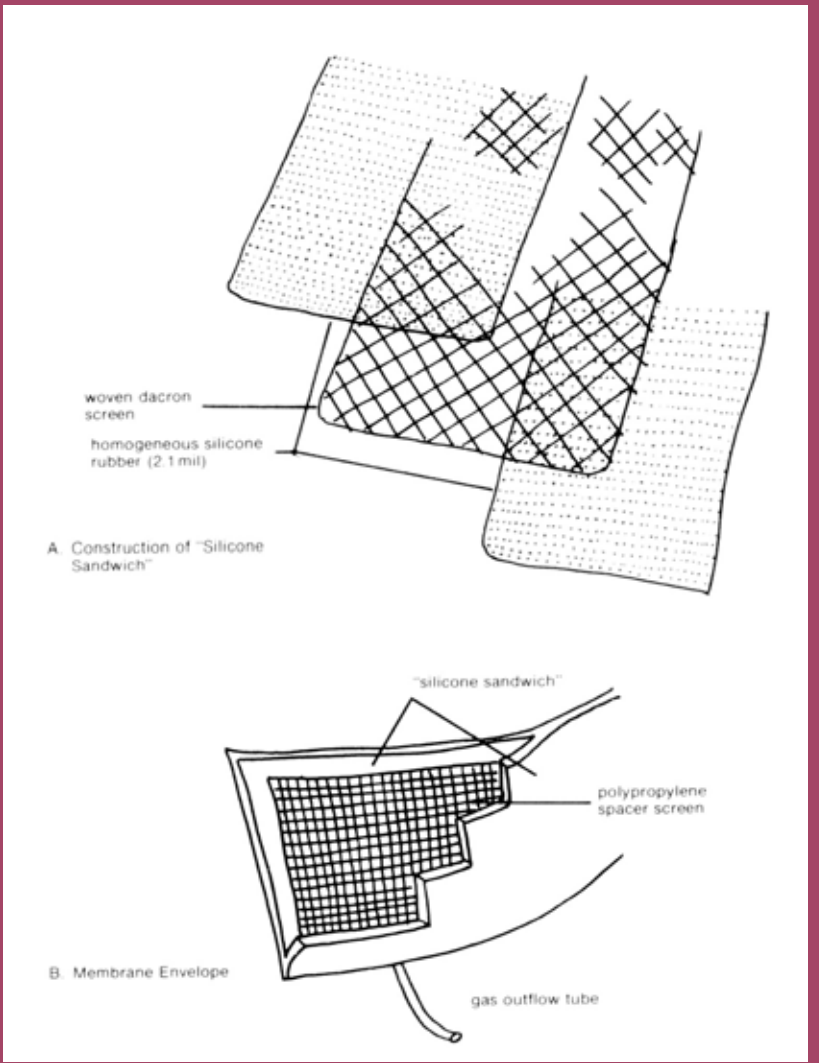
$Quadrox_D$:

- 1 size
- Polymethylpentene hollow fibres
- “True” membrane

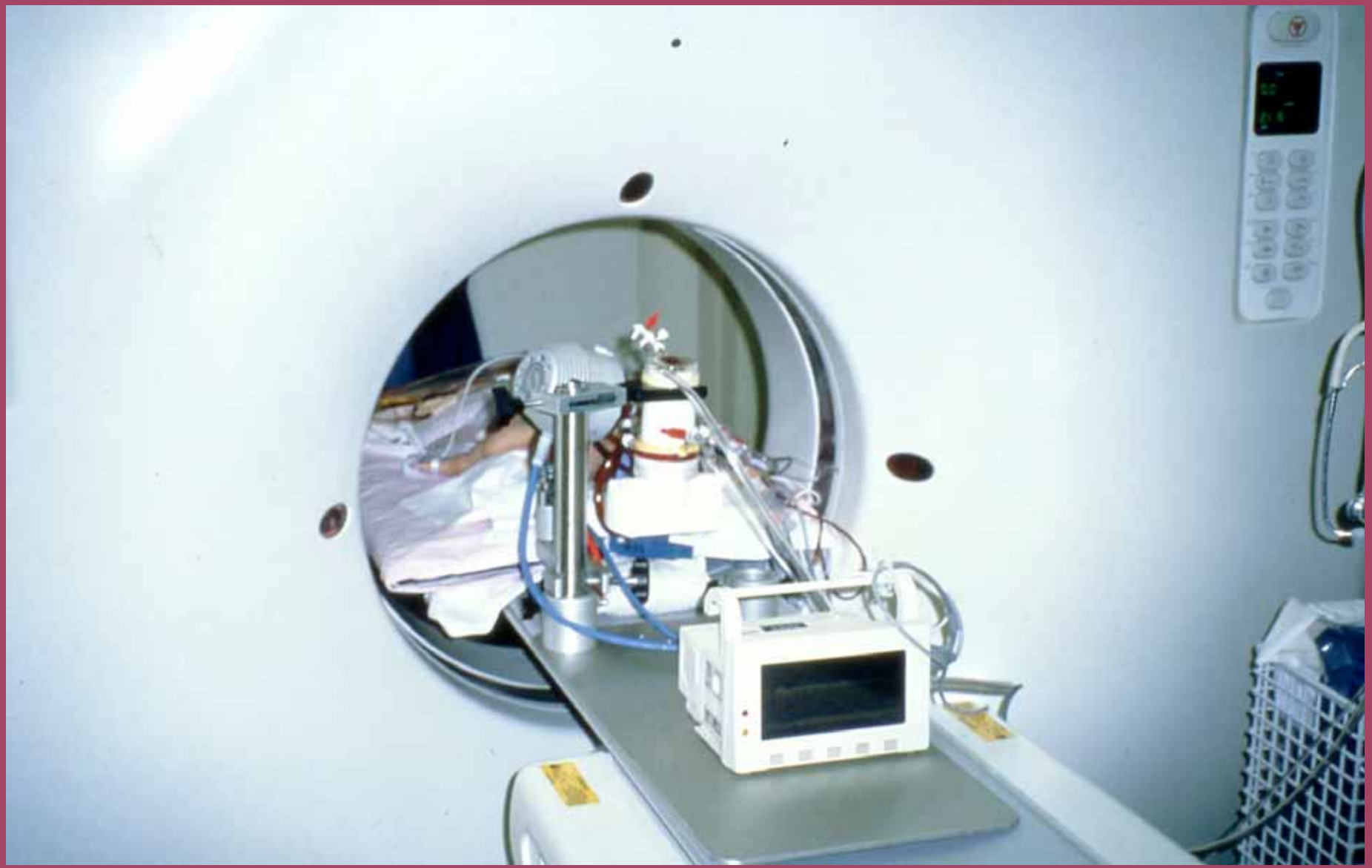
Avecor Oxygenator



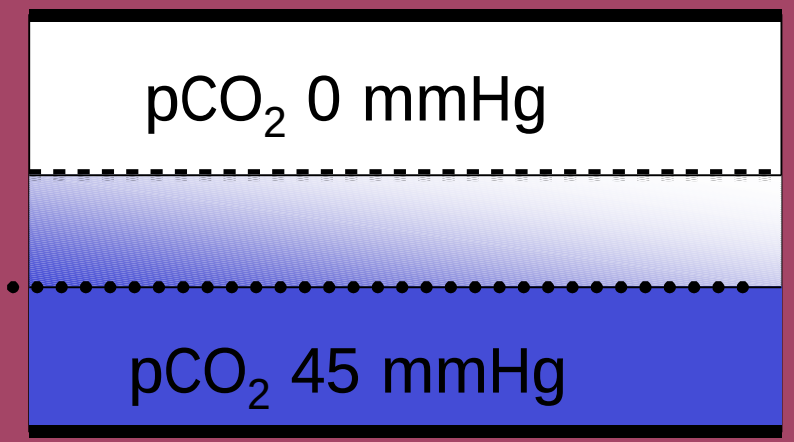
Avecor Oxygenator



SCAN on ECMO



The Silicone Membrane

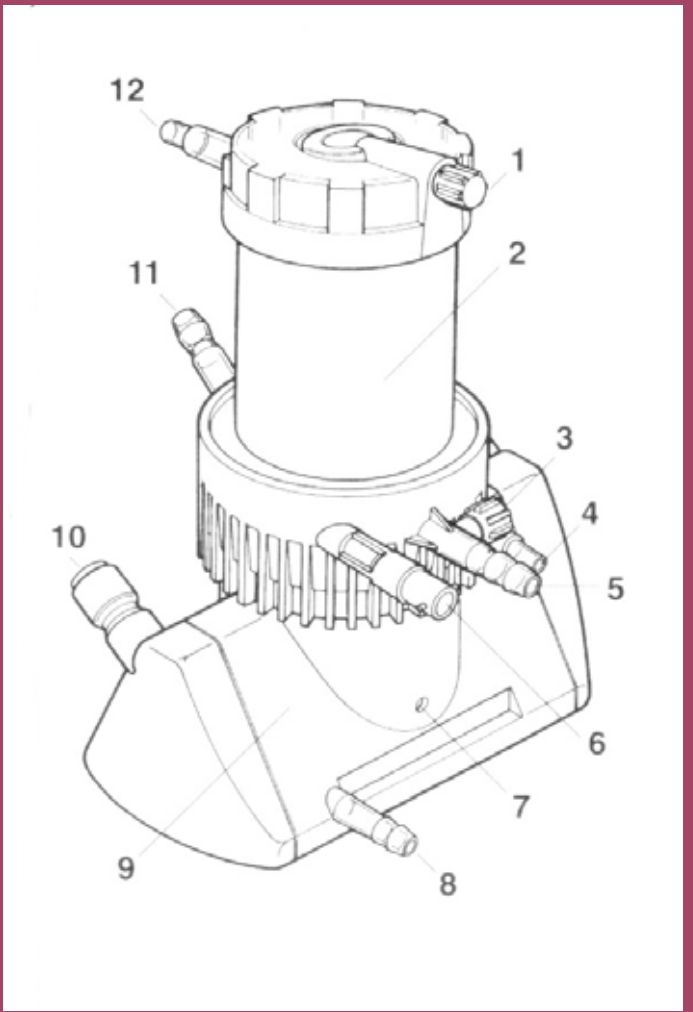


Gas phase

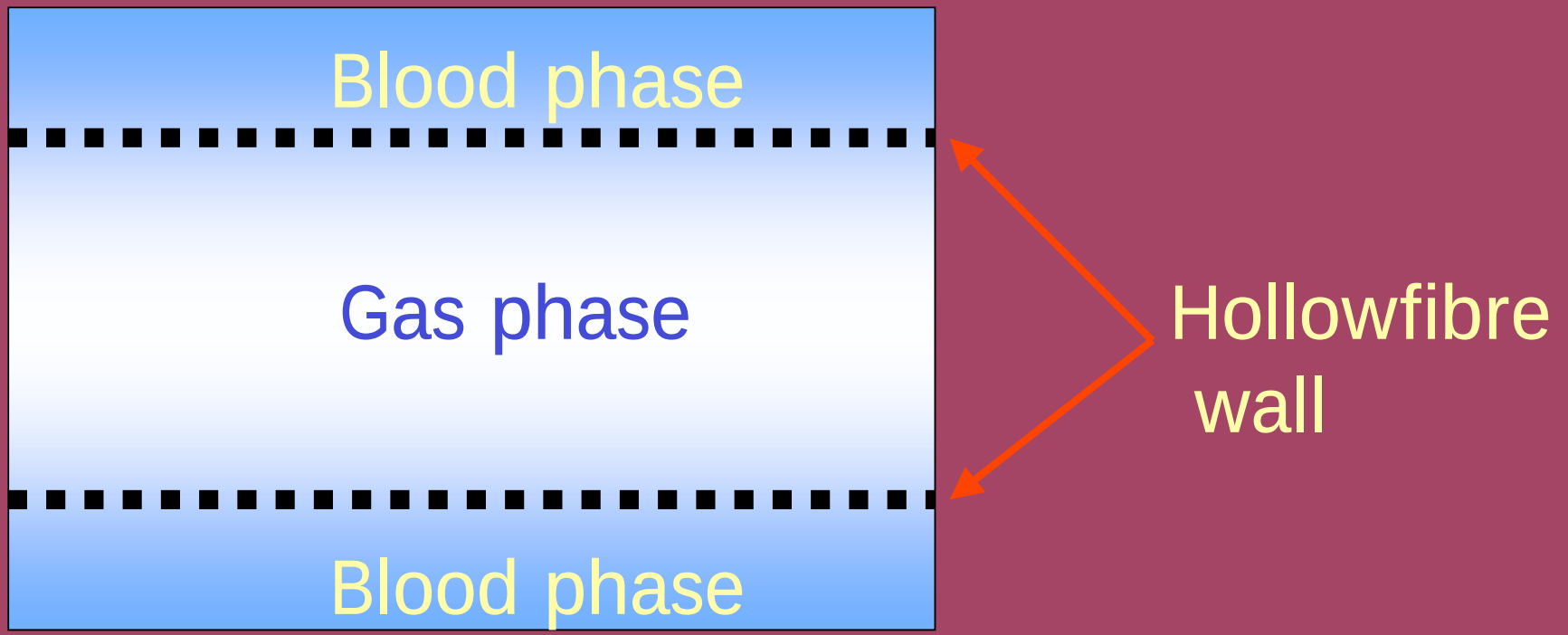
Membrane

Blood phase

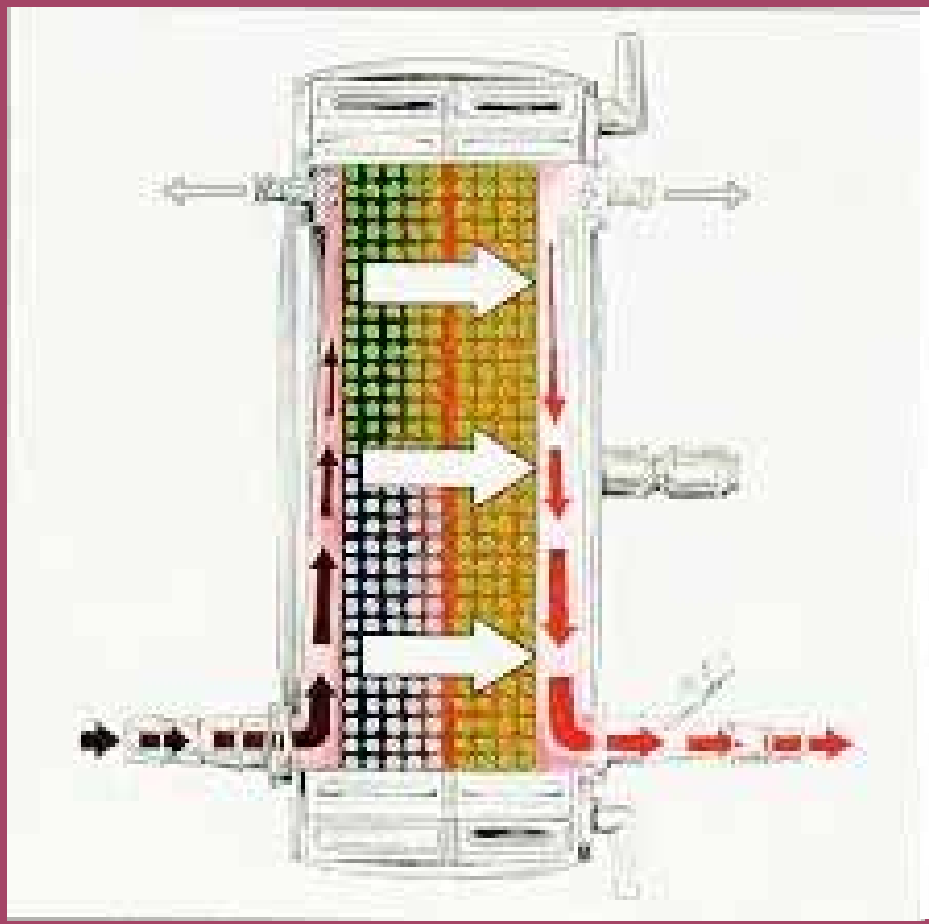
Minimax/Maxima Oxygenator

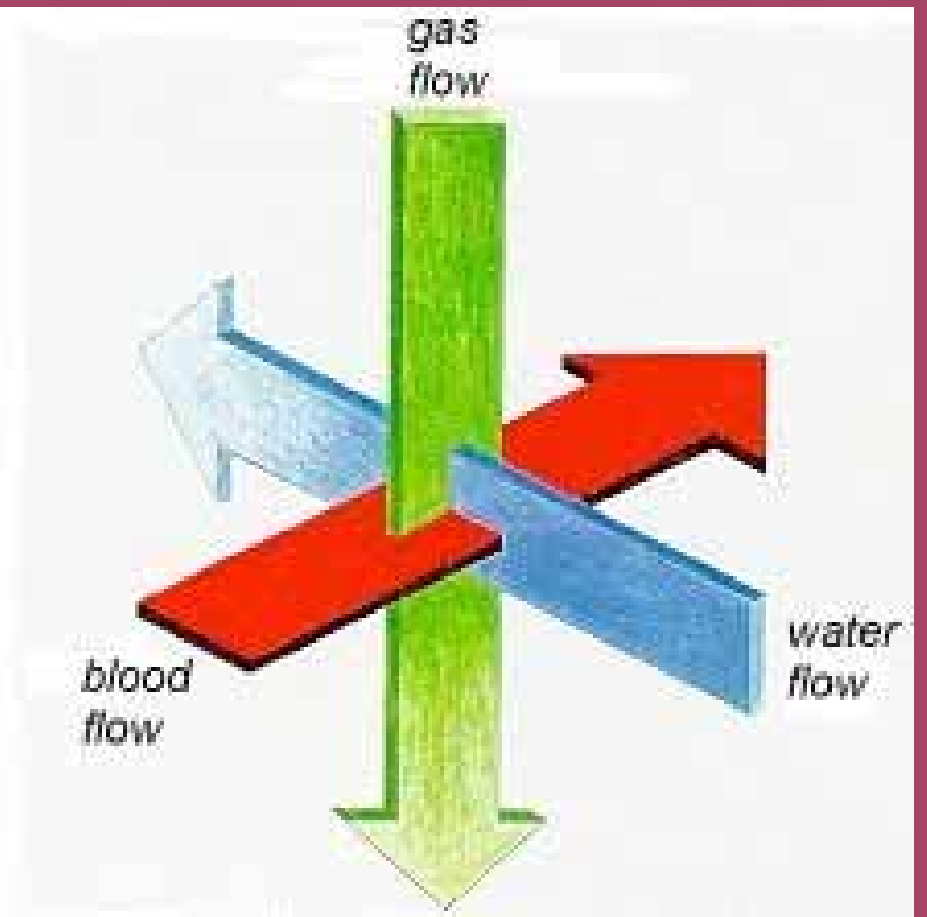


The Hollow Fibre



Quadrox$_D$ Hollow fibre Oxygenator

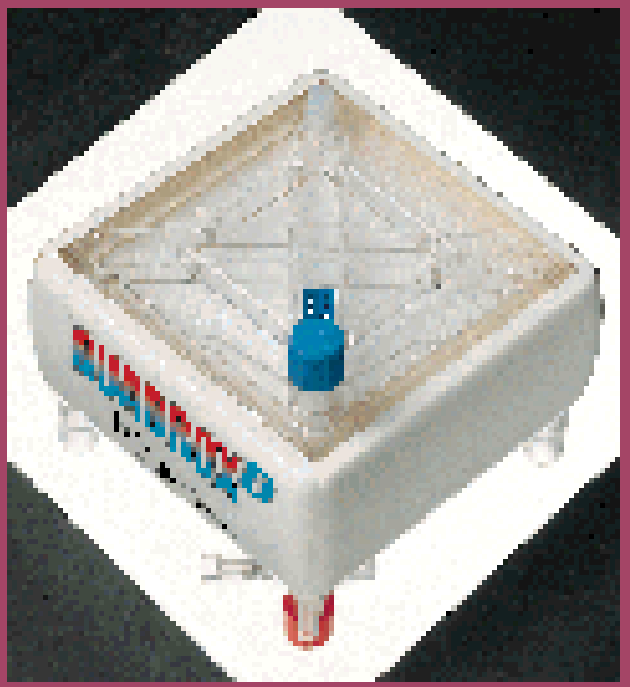




The QUADROX$_D$ Oxygenator with an innovative Diffusion Membrane

- now available with BIOLINE Coating -

Leading-edge Efficiency



The QUADROX$_D$ oxygenator with its tight hollow-fibre membrane made of polymethylpentene and with all the outstanding handling characteristics and high performance of the QUADROX oxygenator.

Technical Data

Blood flow rate	0.5 - 7 l/min
Total priming volume	250 ml
Effective surface area gas exchange	1.8 m_
Material of oxygenation membrane	Polymethylpentene
Effective surface area heat exchange	0.6 m_
Material of heat exchange capillary	Polyethylene

Comparative Data at 4 l/min blood flow

Transfer of oxygen	288 ml/min
Transfer of carbon dioxide (1:1)	207 ml/min
Performance factor heat exchanger (water flow 10 l/min)	0.83
Pressure drop blood side (37°C)	40 mmHg

The innovative diffusion membrane providing constant safety:

- eliminating plasma leaks
- preventing the crossing of micro bubbles

Gas Exchange

Oxygen exchange depends on:

- Type of membrane & diffusion characteristics
- Thickness of the blood pathway
- Surface area of the membrane
- FiO_2 in the gas phase
- Rate of blood flow
- & not fresh gas flow

Gas Exchange

Carbon Dioxide exchange depends on:

Difference in CO_2 conc. between blood & gas

Size of membrane

Fresh gas flow

Blood pathway thickness

Blood flow rate

Heat Exchangers

Avecor 0800, 1500

Inserted in the circuit separately.

Avecor 2500, 3500

Integral with the body of the oxygenator

Jostra Quadrox$_D$,
Medtronic Minimax and Maxima

Incorporated in the body of the oxygenator

Temperature Maintenance

42° C maximum blood temp

Limitation of the ECMO heater:
it doesn't cool.

What about the hyperthermic patient?
Is the patient heating the water?

Cannulae

Direct: inserted into the carotid artery and jugular vein

Percutaneous: inserted into the femoral artery and vein

Bypass: inserted into the aorta and, vena cavae or RA

Gas Delivery

- Sechrist Blender
  - O_2 control
  - CO_2 control
- Pressure relief valve
- Gas filter

Circuit Set-up

Which oxygenator & circuit?

- Patient weight, height, surface area
- Calculate flow rate
  - Oxygenation, circuit tubing
  - Pump head, desired cannulae

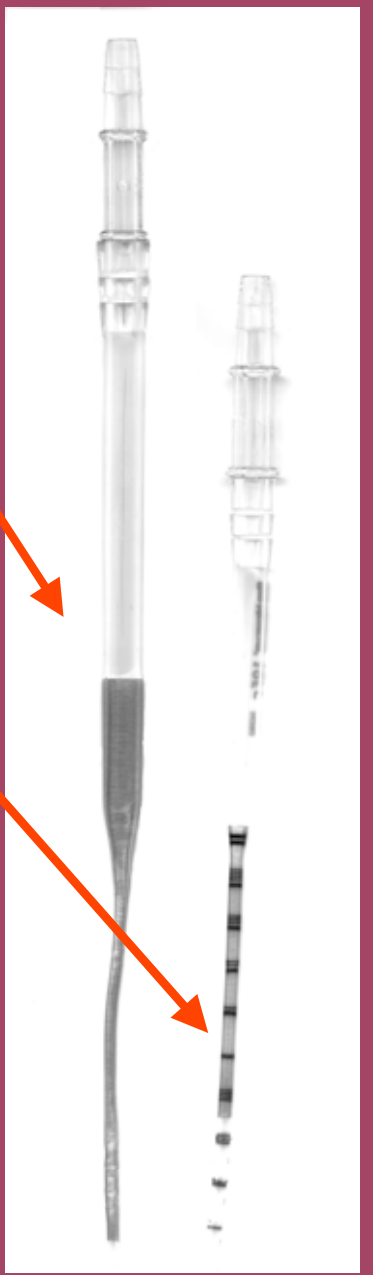
Priming

- Assemble circuit
- CO_2 flush
- Apply vacuum
- Add crystalloid
- Debubble
- Wait
- Add albumin
- Circulate
- Clamp
- Add blood

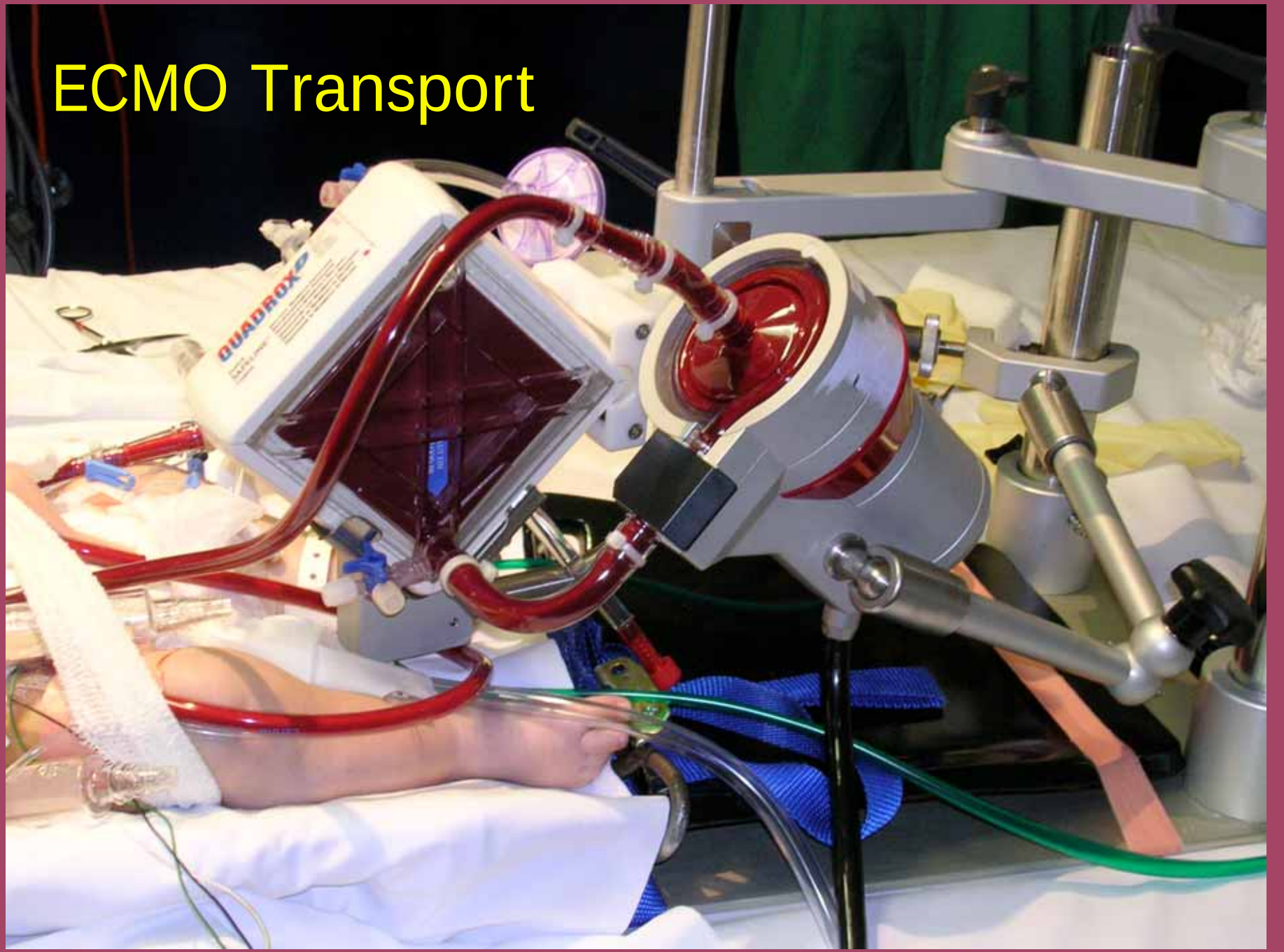
ECMO Cannulae

Aortic: wire wound almost to tip, single outlet hole

Venous: shorter wire wound section, multiple inlet holes



ECMO Transport




The reward at the end of the day.
A happy healthy child.