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 atelectasis
  → ↑ respiratory effort
  → ↑ atelectasis
  → 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
  - atelectasis
- 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…

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…

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
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/m²/min (others)

m² = 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:\n• 1 size
• Polymethylpentene hollow fibres
• “True” membrane
Avecor Oxygenator

A. Construction of "Silicone Sandwich"
- woven dacron screen
- homogeneous silicone rubber (2.1 ml)

B. Membrane Envelope
- polypropylene spacer screen
- gas outflow tube
SCAN on ECMO
The Silicone Membrane

\[ \text{pCO}_2 \ 0 \ \text{mmHg} \]

\[ \text{pCO}_2 \ 45 \ \text{mmHg} \]

Gas phase

Membrane

Blood phase
Minimax/Maxima Oxygenator
The Hollow Fibre

Blood phase

Gas phase

Blood phase

Hollowfibre wall
Quadrox® Hollow fibre Oxygenator
The QUADROX® Oxygenator with an innovative Diffusion Membrane - now available with BIOLINE Coating -

Leading-edge Efficiency

The QUADROX<sub>D</sub> 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

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Blood flow rate</td>
<td>0.5 - 7 l/min</td>
</tr>
<tr>
<td>Total priming volume</td>
<td>250 ml</td>
</tr>
<tr>
<td>Effective surface area gas exchange</td>
<td>1.8 m_</td>
</tr>
<tr>
<td>Material of oxygenation membrane</td>
<td>Polymethylpentene</td>
</tr>
<tr>
<td>Effective surface area heat exchange</td>
<td>0.6 m_</td>
</tr>
<tr>
<td>Material of heat exchange capillary</td>
<td>Polyethylene</td>
</tr>
</tbody>
</table>
## Comparative Data at 4 l/min blood flow

<table>
<thead>
<tr>
<th>Description</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transfer of oxygen</td>
<td>288 ml/min</td>
</tr>
<tr>
<td>Transfer of carbon dioxide (1:1)</td>
<td>207 ml/min</td>
</tr>
<tr>
<td>Performance factor heat exchanger (water flow 10 l/min)</td>
<td>0.83</td>
</tr>
<tr>
<td>Pressure drop blood side (37°C)</td>
<td>40 mmHg</td>
</tr>
</tbody>
</table>

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 Quadroxₐ, 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
- CO₂ 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
The reward at the end of the day.
A happy healthy child.