VV-ECMO

ECMO Physiotherapy Network
July 2016
Veno-Venous ECMO

• Indicated for potentially reversible, life-threatening forms of respiratory failure when adequate heart function is anticipated for the duration of ECMO.

• Venous blood is drained, circulated through oxygenator membrane and returned to the venous circulation
Indications for V-V ECMO

- **Common**
  - Severe pneumonia
  - ARDS
  - Pulmonary contusion

- **Possible**
  - Alveolar proteinosis
  - Smoke inhalation
  - Status asthmaticus
  - Airway obstruction
  - Aspiration syndromes
Predominant Indication: Severe ARDS
Referral Criteria

- Potentially reversible severe acute respiratory failure
- Murray Score >3 (see below)

<table>
<thead>
<tr>
<th>Score</th>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Quadrants of CXR shadowed</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>P/F ratio</td>
<td>≥300</td>
<td>225-299</td>
<td>175-224</td>
<td>100-174</td>
<td>&lt;100</td>
</tr>
<tr>
<td>PEEP</td>
<td>0-5</td>
<td>6-8</td>
<td>9-11</td>
<td>12-14</td>
<td>≥14</td>
</tr>
<tr>
<td>Compliance</td>
<td>≥80</td>
<td>60-79</td>
<td>40-59</td>
<td>20-39</td>
<td>&lt;20</td>
</tr>
</tbody>
</table>
VV-ECMO Contra-indications

- Progressive and non-recoverable respiratory disease (irrespective of transplant status)
- Chronic severe pulmonary hypertension
- Advanced malignancy
- Graft versus host disease
- Unwitnessed cardiac arrest
- Severe (medically unsupportable) heart failure
- Severe pulmonary hypertension and RVF (mean PA approaching systemic)
- Severe immunosuppression (transplant recipients >30 days, advanced HIV, recent diagnosis of haematological malignancy, BMT recipients)
Relative Contra-indications

- Age >70
- Trauma with multiple bleeding sites
- CPR duration >60 min
- Severe multiple organ failure
- CNS injury
- Duration of conventional mechanical ventilation >7 days
- Body size <20 kg or >120 kg
  - The boundaries of upper weight limit are quite flexible and depend on ability to cannulate the patient
Purpose of VV-ECMO

• Rescue therapy
  – For patients who are difficult/impossible to ventilate conventionally
  – For life threatening hypoxaemia

• Lung rest
  – For patients receiving injurious ventilatory strategy to achieve acceptable gas exchange
  – For extensive barotrauma or pneumothorax or air leak

• Bridge to transplant
  – For those already on lung transplant list eg. CF population
Physiology of ECMO

• In the initial period, the lungs do not contribute to gas exchange due to extensive lung pathology
• Gas exchange is performed by the membrane oxygenator in the ECMO system
• Any venous blood not entering the ECMO circuit will be “shunted” through an airless lung
Typical Initial CXR on ECMO commencement – note no contribution to gas exchange via the lungs.
Shunt during ECMO

- In the acute phase, blood is oxygenated via ECMO only (not via lungs due to pathology).
- The only way to increase SaO2 is to increase ECMO flow/decrease shunt flow and increase circuit FiO2.

Deoxygenated “shunt” blood
Oxygen delivery (DO$_2$)

\[ \text{DO}_2 = \text{CaO}_2 \times \text{CO} \]

[ml/min]

\[ \text{CaO}_2 = (\text{sO}_2 \times \text{Hb} \times 1.34) + (\text{PO}_2 \times 0.003) \]

Preload
Heart rate
Contractility
SVR

\( \text{CaO}_2 = \) oxygen content of arterial blood [normal 15.8 - 22.3 ml/dl]
\( \text{CO} = \) cardiac output
\( \text{SVR} = \) systemic vascular resistance
Oxygen delivery during ECMO

\[ \text{DO}_2(\text{total}) = \text{DO}_2(\text{ECMO}) + \text{DO}_2(\text{Lung}) \]

• From lungs depends on
  – Cardiac output
  – Alveolar recruitment (shunt), Lung compliance
  – Ventilator FiO₂
  – Mean airway pressure, PEEP

• From membrane oxygenator depends on
  – Blood flow/Shunt fraction
  – Sweep flow
  – Sweep FiO₂
  – Oxygenator efficiency
Hypercapnia and ECMO

Sweep gas flow relative to blood (pump) flow determines PaCO2
VV-ECMO Configuration

• Different ECMO centres use different configurations dependent upon operator preference and patient factors (e.g., obesity, limb perfusion).

• Most common configurations are:
  – Bifemoral
  – Femero-jugular
  – Avalon cannula (dual lumen jugular)
VV-ECMO: Bifemoral
VV-ECMO: Fem/Jug & Avalon

- Femoral-Jugular Configuration
- Avalon Dual (Jugular) Cannulation
Access cannula to inferior vena cava via femoral vein

Return cannula to superior vena cava via jugular vein
Parts of an ECMO Machine

- Pump
- Membrane Oxygenator
- Console
- Oxygen Blender
Typical Initial ECMO Settings

• Pump/Blood Flow: 4-6 l/min
  – Controlled by increasing pump speed (rpm)
  – Influences oxygenation
• Sweep Flow: 7-10 l/min
  – Influences CO2 clearance
• Sweep FiO2: 1.0
Weaning from ECMO

- As lung function recovers, ECMO support can be reduced
- Pump/blood flow usually remains >3 l/min to prevent clots
- Sweep Fi02 remains 1.0
- Weaning occurs by reducing Sweep Flow
  - This reduces contribution of membrane oxygenator to gas exchange.
- Trail off sweep flow
  - With blood still circulating via ECMO circuit but no contribution to gas exchange externally
  - “Tests” whether patient can manage without ECMO support
Mechanical Ventilation During VV-ECMO

• Most patients are mechanically ventilated
  – Ultra-protective ventilation strategy TVs <6 mls/kg
  – Typical settings 10 PEEP + 10 inspiratory pressure = peak pressures 20cmH20
  – Increased sweep flow is used for CO2 clearance rather than increasing minute volume which may be injurious

• Some patients are awake, spontaneously breathing without mechanical ventilation
Physiotherapy Management During VV-ECMO

• See ECMO Physiotherapy Network consensus document.