ECMO: Indications and Outcomes

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Extracorporeal membrane oxygenation (ECMO) is a temporary mechanical support system used to aid heart and lung function in patients with severe respiratory or cardiac failure.(1) Developed as an offshoot of cardiopulmonary bypass and the membrane oxygenator, ECMO can be used in patients of all ages (newborn to adult). In 1972, Hill et al published the first report of ECMO use in an adult with post-traumatic respiratory failure.(2) In 1979, a randomized clinical trial comparing ECMO to conventional ventilator therapy for acute respiratory distress syndrome failed to show improved outcomes with ECMO use, resulting in the abandonment of the technique for support of adults with respiratory failure.(3) Increased interest in ECMO use in newborns and children with respiratory failure was spurred in the 1980s when Bartlett et al and O’Rourke et al showed improved outcomes for these populations.(4,5) ECMO is now used to support cardiorespiratory dysfunction in a variety of diseases, including sepsis, and as an adjunct to cardiopulmonary resuscitation in many centers worldwide. This article will provide a general overview of ECMO use and outcomes.

The Extracorporeal Life Support Organization (ELSO) was established in 1989; its data registry, vital in advancing the clinical use of ECMO, was established in 1984. Currently, 141 centers report patient, technology and complication data to the registry, providing valuable insight into ECMO use.

ECMO Circuit, Cannulation and Conduct

The ECMO circuit consists of a cannula to drain deoxygenated blood from the patient, as well as a pump, an artificial lung to provide oxygenation and ventilation, heat exchanger, and second cannula to return oxygenated blood back to the patient, as shown in Figure 1.

Figure 1.
Blood is drained into the ECMO by gravity, pumped into the membrane for gas exchange, and returned to the patient after re-warming it to body temperature.

Veno-arterial ECMO (VA ECMO) and venovenous ECMO (VV ECMO) are the two support types. In VA ECMO, deoxygenated blood is drained from the venous circulation into the circuit; it passes through a membrane oxygenator and is returned directly into the arterial circulation, supporting both lung and heart functions. In VV ECMO, deoxygenated blood from the venous circulation is drained into the ECMO circuit, oxygenated, and returned to the right atrium, offering only respiratory support. Adequate circulation is provided by the intact native cardiac function.

The pumps (roller or centrifugal) and oxygenators (polymethylpentene hollow-fiber membrane or silicone membrane) used to configure the ECMO circuit vary widely among institutions. Cannulation sites depend on age, size and indication. Venous cannulation sites include the internal jugular veins, femoral veins and the right atrium. Arterial cannulation sites employ the carotid arteries, femoral arteries and the aorta. The extrathoracic peripheral vessel sites are most commonly used. Intrathoracic cannulation of the right atrium and aorta is commonly used in children who have undergone recent cardiac surgery via a sternotomy.

Unfractionated heparin infusion is used for anticoagulation to prevent circuit thrombosis and embolism. ECMO settings are adjusted to provide mechanical ventilation with low-tidal volumes and inspiratory pressure (“rest settings”) in an effort to avoid ventilation-induced lung injury and oxygen toxicity in patients supported by either VA or VV ECMO. In patients supported with VA ECMO, where native cardiac function contributes to the total cardiac output, providing mechanical ventilation to oxygenate blood ejected to the lungs from native cardiac function may provide the coronary circulation with oxygenated blood, improving the odds of myocardial recovery.

Because mortality rates increase with ECMO duration, prompt weaning is required and should begin as soon as the primary illness has resolved and it is clear that cardiorespiratory function can be maintained independently. The need for longer ECMO support may indicate irreversible cardiorespiratory dysfunction and poor prognosis. Patients who cannot be weaned off ECMO should undergo careful evaluation to justify continued support. Transplantation should be considered for suitable patients with primary heart disease.

Guidelines and policies for the clinical management of patients supported with ECMO vary among individual institutions, as do the specialists charged with caring for the ECMO circuit. The ELSO has published guidelines and training requirements that may serve as a helpful aid for centers seeking to implement an ECMO service.

**ECMO Indications**

ECMO support is only deployed when conventional therapies have failed to support the function of the heart and lungs adequately and when risk of mortality is high and imminent.(1) ECMO is a support modality, not a treatment; it is only beneficial in patients whose primary disease is reversible. ECMO has been used to support primary or secondary diseases that cause respiratory or cardiac failures in newborns, children and adults. It may be used to bridge patients with heart failure as they await heart transplantation or placement of a long-term circulatory support device, such as a ventricular assist device. ECMO utilization also is emerging as an adjunct to cardiopulmonary resuscitation (ECPR).(7,8) In patients with cardiac arrest failing to respond to conventional therapies, initiation of ECMO may promote survival by allowing for investigation and treatment of the cause. Here again, ECMO is merely a support modality and does not treat the cause of arrest or primary illness.(9) It is generally agreed that premature newborns (<32 weeks’ gestation) and those who are small in size (<2 kg) will not benefit from ECMO, nor will patients who have an irreversible cause of critical illness, advanced multi-organ failure, increased risk of bleeding, or severe neurological injury that limits the quality of life.(6)
ECMO Outcomes

Table 1 demonstrates current ECMO outcomes from the ELSO registry database.

### Table 1.

<table>
<thead>
<tr>
<th>ECMO Indication</th>
<th>Number of ECMO Uses</th>
<th>Survival to Hospital Discharge</th>
</tr>
</thead>
<tbody>
<tr>
<td>Neonatal (&lt;30 days)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Respiratory</td>
<td>23,558</td>
<td>75%</td>
</tr>
<tr>
<td>Cardiac</td>
<td>3,909</td>
<td>39%</td>
</tr>
<tr>
<td>ECPR</td>
<td>537</td>
<td>38%</td>
</tr>
<tr>
<td>Pediatric (30 days – 16 years)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Respiratory</td>
<td>4,376</td>
<td>56%</td>
</tr>
<tr>
<td>Cardiac</td>
<td>4,776</td>
<td>47%</td>
</tr>
<tr>
<td>ECPR</td>
<td>1,003</td>
<td>39%</td>
</tr>
<tr>
<td>Adult (&gt;16 years)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Respiratory</td>
<td>1,860</td>
<td>52%</td>
</tr>
<tr>
<td>Cardiac</td>
<td>1,131</td>
<td>34%</td>
</tr>
<tr>
<td>ECPR</td>
<td>408</td>
<td>27%</td>
</tr>
</tbody>
</table>

*ECMO, extracorporeal membrane oxygenation; ECPR, extracorporeal membrane oxygenation with cardiopulmonary resuscitation. Reprinted, with permission, from the 2011 International Report of the Extracorporeal Life Support Organization’s Data Registry.\(^{13}\)

(10) When interpreting survival outcomes following ECMO, it is important to remember that conventional medical therapies have failed these patients, who now face a high risk of imminent death. The best survival-to-hospital discharge rate is among newborns supported with ECMO for neonatal respiratory failure (75%). Survival for adults with severe respiratory failure is 52%.(11) The randomized Conventional Ventilation or ECMO for Severe Adult Respiratory Failure (CESAR) Trial showed improved survival for patients supported with ECMO.(12) Furthermore, survival outcomes following the use of ECMO in patients with acute respiratory failure during the H1N1 influenza pandemic have validated the role of ECMO as an important management strategy in adults with severe respiratory failure.(13)

ECMO complications – which can lead to mortality, morbidity, long-term disability and reduced quality of life – include surgical and organ bleeding, renal and multi-organ failure and central nervous system problems. Clots in the ECMO circuit and mechanical problems may also cause complications. These issues underscore the need for careful conduct when implementing ECMO in specialized units under the guidance of experienced and well-trained healthcare providers.

**Conclusions**

When instituted early and conducted expertly in specialized units, ECMO is a lifesaving therapy in patients with reversible cardiac or respiratory failure. Future research should aim to improve ECMO technology and assess long-term outcomes for survivors.

**References:**


**Disclosures:**

*Author has no disclosures to report

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