Extracorporeal Life Support Organization (ELSO)

Indications for Pediatric Respiratory Extracorporeal Life Support

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Disclaimer

These guidelines describe useful and safe practice for extracorporeal life support (ECLS, ECMO) but these are not necessarily consensus recommendations. These guidelines are not intended as a standard of care, and are revised at regular intervals as new information, devices, medications, and techniques become available. These guidelines are intended for educational use to build the knowledge of physicians and other health professionals in assessing the conditions and managing the treatment of patients undergoing ECLS / ECMO. These guidelines are not a substitute for a health-care provider's professional judgment and must be interpreted with regard to specific information about the patient and in consultation with other medical authorities as appropriate. In no event will ELSO be liable for any decision made or action taken in reliance upon the information provided through these guidelines.

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Extracorporeal membrane oxygenation, ECMO, ELSO, ECLS, extracorporeal life support, pediatric, respiratory failure, hypoxemia, hypercapnia

Introduction

From 2-4 weeks after birth, the residual features of fetal circulation have usually disappeared and children become at risk of a different group of lung diseases. Common indications for extracorporeal life support (ECLS) in neonates such as persistent pulmonary hypertension of the newborn, congenital diaphragmatic hernia, and meconium aspiration are replaced by pulmonary infection, aspiration and acute respiratory distress syndrome (ARDS) in older children. The most common cause of hypoxemic respiratory failure requiring ECLS in children beyond the neonatal period is viral pneumonia (1). When assessing children with respiratory failure for ECLS, it is important to establish that the disease is potentially reversible. Fortunately, this is the case in the vast majority of children. Irreversible lethal lung conditions such as alveolar capillary dysplasia or surfactant protein B deficiency are exceptionally rare and usually present in the neonatal period. Older children with irreversible conditions such as cystic fibrosis may be suitable candidates for ECLS, either as supportive treatment for acute exacerbations or as a bridge to lung transplantation.

The underlying disease is not the only consideration when evaluating the need for ECLS but also an assessment of (i) gas exchange in relation to current levels of mechanical ventilation, (ii) the rate of deterioration, and (iii) the success of other rescue therapies. Specific cut-offs at which ECLS should be offered or withheld have not been firmly established and therefore it should be evaluated on a case-by-case basis.

Indications

The selection of pediatric patients (>30 days and <18 years) with respiratory failure for ECLS is founded on a set of criteria that have evolved over time and have historically predicted high mortality (2). ECLS should be considered in patients with marginal or inadequate gas exchange at risk of ventilator-induced lung injury and who are failing less invasive therapy. Specifically:

- severe respiratory failure as evidenced by sustained PaO_2/FiO_2 ratios <60-80 or OI>40

$$OI = \frac{\text{mean airway pressure } (cmH_2O) \times FiO_2\ (\%)}{PaO_2\ (mmHg)}$$

- lack of response to conventional mechanical ventilation ± other forms of rescue therapy (eg. high frequency oscillatory ventilation (HFOV), inhaled nitric oxide, prone positioning)
- elevated ventilator pressures (eg. mean airway pressure >20-25 on conventional ventilation or >30 on HFOV or evidence of iatrogenic barotrauma)

Other considerations include:

- Hypercapnic respiratory failure:
  Severe, sustained respiratory acidosis (eg. pH<7.1) despite appropriate ventilator- and patient- management may be the primary indication for ECLS (eg. refractory asthma), or may prompt earlier ECLS in patients with co-existent hypoxia and ventilation difficulties. Specific extracorporeal carbon dioxide removal devices may be appropriately deployed in the absence of concomitant hypoxia.
- Rate of deterioration and how quickly ECLS can be initiated:
  Clinicians working in centers without the capacity to facilitate rapid ECLS (<30-45 minutes) should refer earlier, particularly if there is rapid deterioration.
- Absence of contraindications (see below).

If the indication for ECLS is severe hypoxia or hypercapnia then venovenous ECLS should be employed, irrespective of the inotrope dose (2,3). However, if the patient has concomitant shock which also necessitates ECLS for mechanical circulatory support, then VA or hybrid veno-venous/veno-arterial (VVA) ECLS is preferred. The latter is more easily achieved in older children. Children outside of the neonatal age range do not require VA ECLS for respiratory failure purely because of a lack of appropriately sized venous cannulas (cf. neonatal patients <2kg) and a wide range of double lumen VV cannulas are now available from several manufacturers. In complex cases, it is important to re-assess and facilitate rapid changes in cannulation strategy, if necessary.

Contraindications

ECLS is being offered to progressively more complex patients and the number of contraindications to ECLS continues to shrink (4). However, ECLS should not be offered if it is likely to be futile. Contemporary contraindications can be categorized as absolute and relative. It is important not to downplay the importance of relative contraindications; these patients should be regarded as inappropriate ECLS candidates except under exceptional or mitigating circumstances. A third group of high risk patients may also be considered in which outcomes with ECLS are generally poor, even although ECLS may not be specifically contraindicated. Patients in this third group should generally be cared for by, or in consultation with, specialized ECLS centers.

Absolute contraindications

- Lethal chromosomal abnormalities (eg. Trisomy 13 or 18)
- Severe neurological compromise (eg. intracranial hemorrhage with mass effect)
- Allogeneic bone marrow transplant recipients with pulmonary infiltrates (4-6, also see "Guidelines for the management of Extracorporeal Membrane Oxygenation (ECMO) in pediatric patients with immunocompromised conditions for respiratory and/or cardiac failure")
- Incurable malignancy

Relative contraindications

- Duration of pre-ECLS mechanical ventilation >14 days (4,7)
- Recent neurosurgical procedures or intracranial hemorrhage (within the last 1-7 days, depending on neurosurgical advice)
- Pre-existing chronic illness with poor long-term prognosis

High risk patients

- Infants with pertussis pneumonia or disseminated herpes simplex (4,8,9)
- Cytomegalovirus infection
- Severe multiorgan failure
- severe coagulopathy or thrombocytopenia

- Repeat ECLS:

  Patients who have already had survived an ECLS run for the same condition are at high risk of poor outcomes from subsequent runs. Complication rates from subsequent ECMO runs are higher (10) and long term neurodevelopmental outcomes and survival may be poor (11,12)

Summary of recommendations:

Extracorporeal life support (ECLS) may be offered to children with hypoxemia and/or hypercapnic respiratory failure unresponsive to other therapies. It is important that ECLS be instituted in a timely manner before severe hypoxia causes end-organ damage or severe hemodynamic instability. In patients with reversible lung disease who are at risk of ventilator-induced lung injury, precise indications for ECLS have not been established but may include PaO_2/FiO_2 <60-80 despite recourse to other rescue therapies, or an oxygenation index (OI) >40. Important contraindications include lethal chromosomal disorders, severe neurological compromise and allogeneic bone marrow transplantation.

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