Extracorporeal Life Support Organization (ELSO)

Guidelines for Neonatal Respiratory Failure

Introduction

This neonatal respiratory failure guideline is a supplement to ELSO's "General Guidelines for all ECLS Cases" which describes prolonged extracorporeal life support (ECLS, ECMO). This supplement addresses specific discussion for neonatal respiratory failure.

This guideline describes prolonged extracorporeal life support (ECLS, ECMO). This guideline describes useful and safe practice, 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.

The background, rationale, and references for these guidelines are found in "ECMO: Extracorporeal Cardiopulmonary Support in Intensive Care (The Red Book)" published by ELSO. These guidelines address technology and patient management during ECLS. Equally important issues such as personnel, training, credentialing, resources, follow up, reporting, and quality assurance are addressed in other ELSO documents or are center-specific.

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Neonatal Respiratory ECLS Cases:

I. Patient Condition

A. Indications

Neonates with severe respiratory failure, refractory to maximal medical management, with a potentially reversible etiology.

This may be indicated by:

1. Oxygenation Index > 40 for >4 hours
   Oxygenation Index: $\frac{\text{Mean airway P} \times \text{FiO2} \times 100}{\text{Post ductal PaO2}}$
2. Oxygenation Index >20 with lack of improvement despite prolonged (>24h) maximal medical therapy or persistent episodes of decompensation
3. Severe hypoxic respiratory failure with acute decompensation (PaO2 <40) unresponsive to intervention
4. Progressive respiratory failure and/or pulmonary hypertension with evidence of right ventricular dysfunction or continued high inotropic requirement

B. Contraindications:

Contraindications for Neonatal Respiratory ECLS are 1.lethal chromosomal disorder (includes trisomy 13, 18 but not 21) or other lethal anomaly, 2.irreversible brain damage, and 3. Uncontrolled bleeding, 4, Grade III or greater intraventricular hemorrhage. Relative contraindications include 1.irreversible organ damage (unless considered for organ transplant), 2. <2 Kg[1], and 3. <34 weeks post-menstrual age because of the increased incidence of increased intracranial hemorrhage.[2] 3. Mechanical ventilation greater than 10-14 days. A fifth relative contraindication is in patients with disease states with a high probability of a poor prognosis. When there is concern to the appropriateness of ECLS, the specific issues should be discussed with the relevant medical subspecialists prior to cannulation. This allows an in-depth discussion as to the risks of the procedure (including the risk of using valuable resources which could be used for others) vs. the potential benefits. There will, however, be situations where time does not allow for a complete evaluation of the full prognosis. In these cases, discussions should occur shortly after cannulation. If ECLS support is not in the patient's best interest, it should be discontinued. In patients with congenital diaphragmatic hernia (CDH), the abscence of a initial period with preductal sat. >85% and a PCO2 < 65mmhg are strongly associated with worse prognosis attributable to pulmonary hypoplasia and constitutes an exclusion criteria for ECMO in some centers.

[1] Revenis ME, Glass P, Short BL: Mortality and morbidity rates among lower birth weight infants (2000 to 2500 grams) treated with extracorporeal membrane oxygenation. J Pediatr 1992, 121(3):452-458.
[2] Hardart GE, Hardart MK, Arnold JH. Intracranial hemorrhage in premature neonates treated with extracorporeal membrane oxygenation correlates with conceptional age. J Pediatr 2004, 145(2):184-9.

II. Vascular Access

Vascular access is achieved by cannulation of the neck in neonates with respiratory failure. See General Protocol for blood flow resistance information.

A. Cannulas

Appropriate Cannulas for the Vast Majority of Neonates on ECLS are:

1. VA: Single Lumen Venous (10Fr, 12Fr or 14Fr) + Arterial (8Fr or 10Fr)
2. VV: Double Lumen (12-16Fr,)
3. Cephalad: A cannula can be placed in the proximal IJ for improved drainage and to decrease venous congestion. 8, 10, Fr cannulas can usually be placed. The larger cannulas are preferred for improved drainage and decreased stasis. Arterial cannula is recommended as the drainage catheter due to the absence of side ports.

III. Management during ECLS

A. Oxygenation: Very high PaO2 can occur with high flow VA bypass. The negative effects of unnecessary hyperoxia are well described in neonates of all gestational ages, additionally in preterm neonates this can cause fibroplasias retinopathy of prematurity, hence, adjusting flow and/or sweep gas to keep the PaO2 under 100 should be considered.

Critically ill newborns placed on VA ECLS are often on high doses of inotropes when ECLS is begun A rapid increase in blood pressure may occur with initiation of ECLS, which can place neonates at increased risk for intracranial hemorrhage, so inotropy should be titrated down appropriately. Alternatively, as these drugs are titrated down, resistance falls and systemic pressure may fall proportionately. If the systemic perfusion pressure is inadequate (low urine output, poor perfusion, elevated lactate) pressure can be increased by adding blood or low doses of pressor drugs. Systemic vasodilatation requiring pressor drugs is common in patients in septic shock. Although the mean arterial pressure may be low, systemic perfusion may be completely adequate.

If systemic oxygen delivery is not adequate (venous saturation less than 65% withelevated blood lactate levels) increase the pump flow until perfusion is adequate. If extra blood volume is required to gain extra flow, it is preferable to transfuse blood or blood products if available rather than adding more crystalloid solution.

B. Ventilator management: Whether the patient is on either VV or VA mode, the ventilator should be managed at low settings to allow lung rest. A common mistake is to try to recruit lung volume during the acute inflammatory stage early in ECLS. Typical rest settings for a neonate on ECLS are, FiO2 0.21-0.3, PIP (15-22), PEEP (5-8), Rate (12-20), I-time (0.5sec). Using low PEEP may lead to alveolar collapse and increased edema. However, if the PEEP is set too high, venous return and, thus, the hemodynamics may be impaired; particularly when the patient is managed in the VV mode. Rest settings are achieved in some centers with high frequency ventilation.

C. Air Leak: Neonates with respiratory failure often have persistent air leak prior to ECLS and some patients will develop air leak while on ECLS. In both situations, air leak will usually resolve with decreasing ventilation settings. Ventilator settings should be decreased until no active air leak is visualized. This often means low CPAP settings or even "capping-off" the ETT for some period. Re-expanding the collapsed lung should be done gently over some period of time depending on the severity of the air leak (usually 24-48hrs).

D. Sedation: Neonates on ECLS can usually be successfully managed with light sedation, typically with as needed narcotic and occasionally a benzodiazepine. Paralysis and high dose continuous narcotic infusions are reserved for the rare ECLS patient, such as a newborn with CDH, that has significant intestinal distension from swallowed air.

E. Bleeding: See General Protocol. Bleeding into the head or brain parenchyma is the most serious ECLS complication. It can be extensive and fatal. Head ultrasounds should be performed every 24hrs for at least the first 5 days in stable neonates on ECLS and then per institution protocol. If the patient is unstable from a hemodynamic or coagulation standpoint, daily HUS should be considered.If bleeding is detected, the degree of bleeding will guide therapy. If available, portable CT scan may provide additional information on severity and progression of hemorrhage without the added difficulty of transporting the patient. For a small bleed, coagulation status will need to be optimized and HUS repeated 2 times per day to detect any extension. For extending bleeds, or bleeds that are moderate, measures to optimized cardiorespiratory support should be undertaken to allow the patient to be weaned from ECMO. For severe intraparenchymal hemorrhage withdrawal of ECLS is indicated because of the poor neurologic prognosis.

F. Procedures: See General Protocol. Unique to neonates is the common reality of CDH repair on ECMO. There remains intra-institutional variation in the ideal timing for CDH repair in ECMO patients. Despite the controversy, CDH repair on ECMO should be performed by a surgeon skilled in procedures on ECMO with special consideration for hemostasis in anticoagulated patients. Many centers routinely add aminocaproic acid infusion or another hemostatic agent perioperatively to minimize bleeding. The retrospective evidence showed that CDH repair after ECMO is beneficial in terms of better survival.

IV. Head imaging

In addition to serial HUS during the ECMO run, a pre-discharge MRI of the brain can be performed as a more sensitive measure of injury.

V. Expected results (per patient and disease category) and long-term follow-up

The International Registry reports an 85% ECLS survival and 75% survival to discharge for neonates placed on ECMO for respiratory failure. As these critically ill newborns are at high risk of neurodevelopmental problems, they should be followed and referred for therapy as indicated.