

Intensive Care Nursery House Staff Manual

Extracorporeal Membrane Oxygenation (ECMO)

DEFINITION: ECMO is temporary support of heart and lung function by partial cardiopulmonary bypass (up to 75% of cardiac output). It is used for patients who have reversible cardiopulmonary failure from pulmonary, cardiac or other disease.

PHYSIOLOGY: Blood is drained from the patient to an external pump which pushes the blood through a membrane gas exchanger (for oxygenation and CO₂ removal) and warmer and returns the blood to the patient's circulation. The method requires heparin anticoagulation of the patient, that is managed by frequent measurements of activated clotting time (ACT). Various devices monitor pressures, flow, and temperature of the ECMO blood and gas circuits, as well as physiological variables in the patient. ECMO can be either:

- (a) **Veno-arterial (VA)**, in which blood is drained from right atrium (via a right internal jugular venous catheter) and is returned to the thoracic aorta (via a right carotid arterial catheter). VA-ECMO provides cardiac as well as pulmonary support.
- (b) **Veno-venous (VV)**, in which blood is drained from right atrium (via side holes of a double lumen catheter) and returned to the right atrium through the end hole of the catheter which is directed towards the tricuspid valve. VV-ECMO requires good cardiac function and avoids cannulation of the carotid artery.

Cannulation for ECMO is done by a Pediatric Surgeon and patient management is by Neonatology. With both forms of ECMO, the ventilator settings are decreased to allow recovery of lungs, but generally PEEP is maintained at higher pressure (e.g., 8 cm H₂O) to prevent atelectasis.

PATIENT SELECTION CRITERIA: Because of the potential risks of ECMO, criteria are designed to select patients with a high predicted mortality with conventional therapy.

Selection criteria include:

- Gestational age ≥ 34 weeks
- Mechanical ventilation for ≤ 14 d
- Weight ≥ 1.8 kg
- Failure of maximal medical management
- Reversible disease
- Predicted mortality $\geq 80\%$ by historical criteria

Exclusion criteria include:

- Major intracranial hemorrhage
- Uncontrollable coagulopathy
- Lethal malformation
- Syndrome with poor prognosis
- Severe neurologic injury

Clinical indications for ECMO include:

- Oxygen index (OI) > 40 on 2 or more arterial blood gas measurements
[OI = (MAP x FiO₂ x 100) \div PaO₂]
- PaO₂ < 40 mmHg for 4 h in 100% O₂
- Intractable metabolic acidosis
- Intractable shock
- Progressive, intractable pulmonary or cardiac failure
- Inability to come off cardiopulmonary bypass at operation

PRE-ECMO ASSESSMENT includes, in addition to chest x-ray and arterial pH and blood gas measurements:

- Physical examination with careful neurological examination
- PT, PTT, fibrinogen, CBC with platelets, electrolytes, Ca, BUN, Creatinine
- Cranial ultrasound
- Echocardiogram
- If patient is dysmorphic, consider emergency Genetics Consult

MANAGEMENT: Initial settings are aimed at bypass of $\geq 50\%$ of cardiac output and are adjusted to maintain adequate oxygenation, blood pressure and acid-base status. With cardiac failure, VA ECMO is the preferred method. Because of recirculation, VV ECMO cannot usually support $>50\%$ of cardiac output, which may limit the ability to adequately oxygenate the patient. Patients on ECMO require frequent measurements of pH and blood gas tensions and various laboratory tests, as well as frequent transfusions with packed RBCs and platelets. Meticulous attention to all aspects of a patient's condition is essential. The infants are sedated, but usually do not require paralysis while on ECMO.* Allowing the patient to move facilitates neurological assessment. As patient improves, ECMO support is gradually reduced. Patient is decannulated when able to tolerate minimal ECMO support on low to moderate ventilator settings. The duration of ECMO treatment is usually limited to 7-10 d for neonatal respiratory diseases, but longer treatment may be needed for newborns with diaphragmatic hernia and cardiac disease and in older children.

*One exception includes patients with **congenital diaphragmatic hernia** prior to operative repair. They are usually kept paralyzed to prevent air swallowing which dilates the bowel, complicates the operation and interferes with pulmonary function.

COMPLICATIONS:

- Hemorrhage (pulmonary, GI, surgical site)
- Cardiac dysrhythmia
- CNS damage (bleeding or infarction)
- Renal failure
- Seizures (metabolic or CNS causes)
- Hyperbilirubinemia
- Fluid retention and severe edema
- Sepsis

OUTCOME: Survival in neonatal patients varies with underlying disease.

<u>Disease Category</u>	<u>Survival</u>
Aspiration syndromes	$>90\%$
Persistent pulmonary hypertension	80%
Infection	65%
Congenital diaphragmatic hernia	50%
Congenital heart disease	40%
Cardiomyopathy	50%

Note: The above comments apply primarily to neonatal patients. Occasionally, older infants and children, and even some adult patients, benefit from ECMO treatment.