Extracorporeal Membrane Oxygenation (ECMO)

ECMO is used for both cardiac and pulmonary failure when conventional measures are no longer effective to support life. Rather than providing a cure for the underlying disease process, ECMO delivers oxygen-rich blood to vital organs, which gives the heart and lungs time to repair. During ECMO, blood is drained from the patient's vascular system and then circulated outside the body by a mechanical pump through an oxygenator and heat exchanger. Carbon dioxide (CO_2) is removed and oxygen-saturated blood is returned to the body.

Types of ECMO

Also known as extracorporeal life support or extracorporeal lung assist, there are two primary types: venovenous (VV) and venoarterial (VA) ECMO. The table below shows a comparison of the two.

Types of ECMO		
	Venovenous (VV) ECMO	**Arteriovenous (AV) ECMO**
Indications (Calhoun, 2018)	• Severe respiratory failure where mechanical ventilation cannot maintain adequate gas exchange • Acute respiratory distress syndrome (ARDS) • CO_2 retention despite full ventilatory support • Infection, such as influenza or pneumonia • Acute pulmonary embolism • Bridge to lung transplant	• Cardiogenic shock • Decompensating heart failure • Failure to wean from cardiopulmonary bypass during heart surgery • Bridge to permanent device, such as LVAD • Bridge to heart transplant • Mixed cardiopulmonary failure (Naddour et al., 2019)
Level of support	Respiratory support, no cardiac support	Both respiratory and cardiac/hemodynamic support
Cannulation (Bartlett, 2020)	Major veins are cannulated to drain and return blood to the body. • Right or left common femoral vein (drainage) and right internal jugular vein (return/infusion) • Femoral vein and femoral vein • Bi-cava, double lumen in internal jugular	Major veins (drainage) and arteries (return) are cannulated. • Inferior vena cava or right atrium (drainage) to right femoral artery (return/infusion) • Femoral vein to femoral artery

		• Right common carotid artery or subclavian may be used, but high risk for cerebral infarction
Blood flow (Bartlett, 2020)	Set near-maximum flow rates to optimize oxygen delivery.	Set flow rate high enough to provide adequate perfusion and oxygen saturation, but low enough to provide enough preload to maintain left ventricular output.

Initiation of ECMO Therapy

Once it has been determined that ECMO will be instituted, the patient is anticoagulated, typically with intravenous (IV) heparin. Cannulation of the vessels is performed; the patient is connected to the ECMO device and blood flow is increased until respiratory and hemodynamic targets are met. These targets may include (Bartlett, 2020):

- Arterial oxyhemoglobin saturation greater than 90% for VA ECMO, or greater than 75% for VV ECMO
- Venous oxyhemoglobin saturation 20-25% lower than the arterial saturation
- Adequate tissue perfusion, as evidenced by arterial blood pressure, venous oxygen saturation, and blood lactate level

Nursing Considerations (Bartlett, 2020; Naddour et al., 2019)

- Hemodynamics
  - When the target parameters have been met, blood flow is maintained at the set rate and oxygen status is assessed by continuous venous oximetry.
  - If oxygenation drops below the target range, consider increasing blood flow, intravascular volume or hemoglobin concentration (Bartlett, 2020). Decreasing patient's temperature to reduce oxygen consumption may be beneficial as well.
  - Left ventricular output may worsen with VA ECMO; inotropes may be used to increase contractility and intra-aortic balloon pump (IABP) will reduce afterload and support left ventricular cardiac output.
  - Monitor central venous pressure and fluid status.
- Anticoagulation and laboratory
  - Maintain anticoagulation with a continuous IV infusion of unfractionated heparin or direct thrombin inhibitor to achieve an activated clotting time (ACT) of 180 to 210 seconds. Reduce the ACT target if bleeding occurs.
  - Monitor platelet counts and maintain level above 50,000/mL.
  - Monitor hemoglobin and maintain level within normal range.
- Ventilator management
  - Adjust ventilator settings to prevent barotrauma, ventilator-induced lung injury, and oxygen toxicity. Typical ventilator settings are FiO_2 less than 50%, positive end expiratory pressure (PEEP) at 5 cm H_2O, tidal volume at 4 mL/kg, respiratory rate at 2 to

5 breaths per minute, and plateau pressure maintained less than 30 cm H_2O (Naddour et al., 2019).
    - Perform strict pulmonary hygiene to prevent ventilator-associated pneumonia.
- Renal management
    - Diuretics are often administered to reduce fluid overload.
    - Oliguric and polyuric phases of acute tubular necrosis are common on ECMO, and continuous renal replacement therapy (CRRT) may be required.
- Monitor for signs of infection and poor perfusion such as increased lactic acid level, metabolic acidosis, decreased urine output and increased liver enzymes.
- Assess for lower limb ischemia: check dorsalis pedis and posterior tibial pulses, and assess for coolness or mottling of feet.
- Administer light sedation as ordered to prevent decannulation.
- Conduct daily wakeup and hourly pupil checks to monitor neurological status.
- Practice diligent patient repositioning to prevent skin breakdown.
- Staffing considerations (O'Connor & Smith, 2018):
    - Staffing models will vary from facility to facility based on staffing experience and ECMO patient volumes; some centers require two staff per one ECMO patient.
    - Pediatric/neonatal patients on ECMO are typically managed by an ECMO specialist. These specialists may include:
        - Registered nurse (RN)
        - Respiratory therapist (RRT)
        - Clinical perfusionist
        - Physician with advanced training in ECMO
    - An alternative staffing model may include a core team of RNs and RRTs within ECMO centers who develop expertise in caring for complex patients.
    - Specialized training will include:
        - Management of the ECMO circuit such as priming the circuit for cannulation and titration of blood flow and sweep gas flow
        - Coordination of fluid, blood and sedation management

Complications (Bartlett, 2020; Naddour et al., 2019)

There are several complications from ECMO therapy that are common and associated with significant morbidity and mortality.

- Bleeding
    - Due to anticoagulation and platelet dysfunction
    - Can occur at multiple sites such as insertion site, surgical site, intra-abdominally, and intracranially
- Thromboembolism
    - Blood clot formation in membrane oxygenator and tubing connections; monitor for changes in the circuit such as dark or white areas around the gas exchange device; a primed replacement circuit should be readily available at the bedside
    - Pulmonary embolism
    - Deep vein thrombosis
- Cannulation-related complications

    - Vessel perforation
    - Arterial dissection
    - Distal ischemia
    - Incorrect location (i.e. venous cannula located within the artery)
    - Venous cannulas too close causing recirculation of blood
- Mechanical complications
    - Oxygenator failure
    - Pump failure
- Heparin-induced thrombocytopenia (HIT) – replace heparin with a non-heparin anticoagulant, such as argatroban.
- VA ECMO-specific complications
    - Pulmonary hemorrhage
    - Cardiac thrombosis
    - Coronary or cerebral hypoxia
    - Neurological injury

Weaning from ECMO (Bartlett, 2020)

Before weaning from ECMO can begin, several criteria should be met. For patients with respiratory failure, monitor for improvement in chest X-ray appearance, pulmonary compliance, and arterial oxyhemoglobin saturation. In patients with cardiac failure, assess for improved left ventricular output. A transthoracic echocardiogram may be performed to evaluate heart function. Trials should be performed before discontinuing ECMO permanently. When the patient is ready, stop the heparin drip 30 to 60 minutes before the cannulas are removed. Following cannula removal, apply pressure to the insertion sites. For VA ECMO, compression should be applied to the arterial site for a minimum of thirty minutes.

References:

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