**Extracorporeal Life Support (ECLS)**

**What is ECLS?**

ECLS encompasses a set of extracorporeal modalities that provide oxygenation, carbon dioxide (CO2) removal, and/or circulatory support that excludes cardiopulmonary bypass for cardiothoracic or vascular surgery. (Abrams, Fried, Agerstrand & Brodie, 2024).

There are distinct variations of ECLS:

- Extracorporeal membrane oxygenation (ECMO)

- Extracorporeal carbon dioxide removal (ECCO2R) (Abrams, Fried, Agerstrand & Brodie, 2024).

ECLS and ECMO are used interchangeably in the literature. There are two main types of ECMO, each serving different clinical purposes based on patient needs. Veno-arterial (VA) ECMO and Veno-venous (VV) ECMO. A simplified circuit consists of a drainage and a reinfusion cannulae, a pump, membrane lung, heat exchanger, oxygen source, blender and connection tubing. The rationale for a simple circuit is to minimize turbulent blood flow that can promote thrombus formation and hemolysis and avoid sites of potential air entrainment, blood loss, or contamination. (Abrams, Fried, Agerstrand & Brodie, 2024).

**Purpose and Indications:**

**V-A ECMO** is the most widely used support modality due to cost, ease of canulation and the ability to provide respiratory and cardiac support. V-A ECMO is used in patients with acute or acute on chronic cardiac or circulatory failure, cardiac arrest, or cardiogenic shock and when both heart and lung support are necessary (Abrams, Fried, Agerstrand & Brodie, 2024; Russo, et al., 2019).

**V-V ECMO**

Provides respiratory support only and facilitates oxygenation and the elimination of CO2. It is used in patients with severe but potentially reversible respiratory failure, that include conditions like acute respiratory distress syndrome (ARDS) and hypercarbia when lung function is compromised but heart function is adequate. The main indications include acute respiratory distress syndrome, severe pneumonia, aspiration, barotrauma, and interstitial pneumonitis. In some cases, such as end-stage pulmonary disease, ECMO can be utilized as a bridge to lung transplantation. (Abrams, Fried, Agerstrand & Brodie, 2024; Bharadwaj & Bora, 2024).

**Cannulation Sites:**

**V-A ECMO**: The circuit configuration of the V-A ECMO is comprised of a drainage cannula that removes blood from the right atrium or a large central vein (e.g., femoral or internal jugular

vein). This blood is oxygenated extracorporeally and reinfused into a major artery, bypassing the heart. This configuration is ideal due to the percutaneous accessibility of these vessels at the bedside and the fact that cannulation is often needed under urgent or emergent circumstances. This intervention is vital in conditions such as cardiogenic shock, biventricular failure, and profound hypoxemia, especially when conventional therapies fail. It is also a bridge for sustaining end-organ perfusion and reducing inotrope-induced damage, while clinicians work toward a definitive solution for the underlying cardiac condition. Cannulation methods for VA ECMO encompass both central and peripheral approaches. (Abrams, Fried, Agerstrand & Brodie, 2024; Bharadwaj & Bora, 2024).

* Central cannulation: is often used in post-cardiotomy patients who cannot be weaned off cardiopulmonary bypass. The venous cannula is placed into the right atrium or a central vein and the arterial cannula into the ascending aorta or another central arterial location. This method is ideal for direct cardiac and pulmonary support during surgeries or complex clinical encounters.
* Peripheral cannulation: is initiated percutaneously and involves inserting the venous cannula into a large peripheral vein, e.g., the femoral vein, and the arterial cannula into a peripheral artery, the femoral artery. This type of cannulation is preferred for rapid initiation in emergency settings or when central cannulation is not practical (Bharadwaj & Bora, 2024).

**V-V ECMO**: The configuration is designed where blood is withdrawn via the drainage cannula from a large vein, such as the femoral, jugular or subclavian vein, oxygenated, and returned to another vein. The oxygenated blood is delivered back to the venous system, circulating through the heart before reaching arterial circulation (Abrams, Fried, Agerstrand & Brodie, 2024; Bharadwaj & Bora, 2024).

Hybrid configurations like venoarteriovenous ECMO (V-AV) provide both cardiac and respiratory support while preventing the risk of proximal aortic arch hypoxemia. This can be achieved by using a Y-connector to split the reinfused blood flow between the arterial and venous systems. Therefore, oxygenated blood can simultaneously supply both the femoral artery for hemodynamic support and the right atrium for upper body gas exchange support (Abrams, Fried, Agerstrand & Brodie, 2024).

**Table 1: Illustration of the types of ECLS, mode and configuration, organs supported**

**and suggested indications in the Intensive Care Unit (ICU)**

|  |  |  |  |
| --- | --- | --- | --- |
| **ECLS type** | **ECLS mode and configuration** | **Organ support and function** | **Suggested indications\*** |
| **ECMO** | **V-V ECMO** | Respiratory support (oxygenation and CO2 removal) | Refractory ARDS, bridge to lung transplant, severe primary graft dysfunction after lung transplant, severe reperfusion pulmonary edema after thrombo-endarterectomy, aspiration |
| **V-A ECMO** | Cardiac/circulatory support (circulatory support, oxygenation and CO2 removal) | Refractory cardiogenic shock, extracorporeal cardiopulmonary resuscitation (ECPR), decompensated pulmonary vascular disease, postcardiotomy shock, (trauma, anaphylactic shock, drowning, organ donation, shock due to overdose, hypothermia) |
| **V-VA ECMO**  **V-AV ECMO** | Cardiorespiratory support | Mixed components of the above indications |
| **ECCO2**R | **V-V ECCO2R**  **A-V ECCO2R** | CO2 removal only | Refractory hypercapnic respiratory failure (e.g., status asthmaticus, bridge to lung transplantation); facilitation of lung protective ventilation strategies in ARDS (under investigation) |

**LEGEND**

|  |
| --- |
| ECLS: extracorporeal life support |
| ECMO: extracorporeal membrane oxygenation |
| V-VA: venovenoarterial V-AV: venoarteriovenous |
| V-V: venovenous V-A: venoarterial A-V: arteriovenous |
| ECPR: extracorporeal cardiopulmonary resuscitation |
| ECCO2R: extracorporeal carbon dioxide removal |

(Abrams, Fried, Agerstrand & Brodie, 2024).

**Table 2: an illustration of Absolute and Relative Contraindications of ECLS**

|  |
| --- |
| **Absolute Contraindications** |
| Severe irreversible noncardiac organ failure or condition limiting survival (e.g., severe anoxic brain injury, end-stage malignancy) |
| No transition to a well-defined end point (e.g., recovery, transplantation, assist device; "a bridge to nowhere") |
| Severe aortic insufficiency\* |
| Aortic dissection |
| **Relative Contraindications** |
| Severe coagulopathy or contraindication to anticoagulation |
| Limited vascular access\*, central nervous system (CNS) hemorrhage |
| Advanced Age ¶, major CNS injuries or pathologies |
| Morbid Obesity ¶ |
| Severe peripheral arterial disease\* |
| Severe immunocompromised status |
| Prolonged duration of mechanical ventilation (e.g., ≥7 days) |
| Lack of resources to support ECMO-associated care |

\* Applies to V-A ECMO.

¶ Cutoff points vary by individual patient characteristics and are usually institution specific.

Δ Applies to V-V ECMO.

(Abrams, Fried, Agerstrand & Brodie, 2024; Bharadwaj & Bora, 2024)

**Table 3: Complications of ECMO by Systems:**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Neurological** | **Pulmonary** | ***Cardiac*** | **Circuit Related** | **Cannula Related** |
| -Intracranial bleeding  -Thromboembolic stroke  -Seizures | -Pulmonary hemorrhage\*  -Pulmonary embolism  -Pulmonary edema | Arrythmias (atrial or ventricular) \*  -Cardiac perforation  -Pericardial tamponade  -Congestive heart failure  -Ventricular distension  -Intracardiac thrombosis | -Thrombosis\*  -Oxygenator failure\*  -Air embolism  -Pump failure  -Hypothermia  -Altered pharmacokinetics (drug sequestration, altered volume of distribution)  -Recirculation | Cannula misplacement  -Vessel perforation  -Cannula site bleeding\* and infection  -Limb ischemia  -Compartment syndrome  -Cannula thrombosis |
| **Hematologic** | **Infections** | **Renal** |  |  |
| -Hemorrhage\*  (cannula site, surgical site, gastrointestinal bleed (GIB), pulmonary, CNS, RP)  -Hemolysis\*  -Disseminated intravascular coagulation (DIC)  -Deep vein thrombosis (DVT) and thromboembolism (systemic, cardiac or pulmonary) \*  -Thrombo-cytopenia (including heparin induced thrombocytopenia (HIT)  -Retroperitoneal hematoma | -Cannula insertion site  -Blood stream infection/bacteremia\* | Acute Kidney injury |  |  |

(Abrams, Fried, Agerstrand & Brodie, 2024)

### **Impact of ECLS on Hemodynamics**

VA-ECMO

- is associated with increase in left ventricular afterload, as it relies on retrograde aortic flow and can have adverse effects including:

- myocardial ischemia

- delayed ventricular recovery

- can lead to LV distension and potentially worsening pulmonary edema as the LV ability to eject blood is reduced

-thrombotic events

-multiorgan dysfunction.

-increased systemic vascular resistance

-coronary flow and perfusion may improve due to the delivery of oxygenated blood, however the increased afterload can be devastating to cardiac patients (Russo et al., 2019).

V-V ECMO:

-does not provide direct hemodynamic support-

-has no impact cardiac output or blood pressure directly

-it only oxygenates blood without influencing systemic circulation.

-it improves systemic oxygenation and can reduce workload on the heart

-Does not increase afterload or affect LV preload and afterload

- complications such as myocardial or cerebral ischemia. This results when deoxygenated blood from the heart mixes with oxygenated ECMO blood in the descending thoracic aorta, lower body receives oxygenated blood and the upper body receives deoxygenated blood (Bharadwaj & Bora, 2024)

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