Review Article

Indian Journal of Surgical Nursing
Volume 9, Number 2 May–August 2020
DOI: http://dx.doi.org/10.21088/ijsn.2277.467X.9220.6

Extra-Corporeal Membrane Oxygenation (ECMO)

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Abstract

Extracorporeal membrane oxygenation (ECMO) is a revamping techniques of conventional cardiopulmonary bypass which provide cardiopulmonary support. It is a form of extra corporeal life support when the persons heart and lungs are fail to provide gas exchange and circulation. In this system a cannula is placed in a large vein which carries deoxygenated blood from patient to a gas exchange device where blood enriched with oxygen and returned to the patient through other circuit. ECMO does not a definitive treatment option for the underlying disease, but it provides physiologic cardiopulmonary support to reversible aspects of the disease process and it promote recovery. Currently the indications for ECMO support ranging from acute respiratory failure to acute cardiac failure when patient is unresponsive to conventional treatments and using it for wide patient subsets involving neonates to adults.[1] The modes of support are either veno-venous or veno-arterial ECMO.

Keywords: Extracorporeal Membrane Oxygenation; Physiology; Venous–Arterial ECMO; Venous–Venous extracorporeal membrane oxygenation; Oxygenation.

How to cite this article:
Sheeja Sebastian, Sr. Philoresmi, Neethu Jose Extra-Corporeal Membrane Oxygenation (ECMO). Indian. J Surg Nurs. 2020;9(2):85–89..

Introduction

ECMO is a life-saving technique which carry out the natural function of the heart and lungs. It pumps deoxygenated blood from the body and oxygenates it in outside the body, allowing the heart and lungs to rest. When patient is connected to an ECMO, deoxygenated blood flows through a cannula to a membrane oxygenator in machine and returned the oxygenated warmed blood to body.[2] The term "extracorporeal life support" (ECLS) denotes prolonged but temporary (1–30 days) physiologic support of heart or lung using mechanical devices.

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ECMO is currently used at specialized centres to support patients with respiratory or cardiac failure who are unresponsive to conventional therapeutic interventions.[1] It provides rest to the organ while natural healing of the affected organs takes place.

Physiological goals of ECMO[1]

(1) Remove CO_2 and oxygenate the blood

(2) Improve tissue oxygen delivery

(3) Allow normal physiologic metabolic milieu at tissue level

(4) Provide lung rest and/or reduce cardiac function

Indication[3]

- As a bridge for recovery from Cardiac failure/ Respiratory failure / heart surgery.
- Support for high-risk procedures in cardiac catheterization lab.
- As a bridge to ventricular assist device (VAD) implantation.
- As a bridge for patients awaiting heart transplantation

- As a bridge for patients awaiting lung transplant

Contraindication[4]

Absolute contraindications

- Neurologic catastrophe(cerebral hemorrhage, infarction, edema)
- Moribund stage/terminal condition with markedly reduced life expectancy < 6 months
- Advanced incurable underlying disease(malignancy, cirrhosis, pulmonary hypertension,)
- Lack of informed consent

Relative contraindications

- Contraindication to anticoagulation(uncontrolled bleeding)
- Advanced age>70 yrs
- Multisystem organ failure
- Duration of mechanical ventilation greater than 7-10 days
- Marked obesity(weight>150 kg:due to excessive flow demands on the circuit)

Risks[5,9]

- Bleeding
- Infection at cannulation sites.
- Transfusion problems, due to emboli formation in the circuit.
- Limb Ischemia
- Air embolism

Candidates for ECMO[3]

Babies:

- Persistent Pulmonary Hypertension
- Meconium Aspiration Syndrome
- Sepsis or infection
- Pneumonia
- Congenital Diaphragmatic Hernia
- Congenital Heart Disease / Post-op Shock Lung
- Hyaline Membrane Disease.

Older children

- Post-op period of Cardiac repair
- Myocarditis
- Sepsis
- Pneumonia
- Aspiration Pneumonia
- Asthma
- Near Drowning
- Hydrocarbon Ingestion (turpentine)

Adults:

- Cardiac failure
- Respiratory Failure
- Bridge to VAD implantation and Heart transplantation

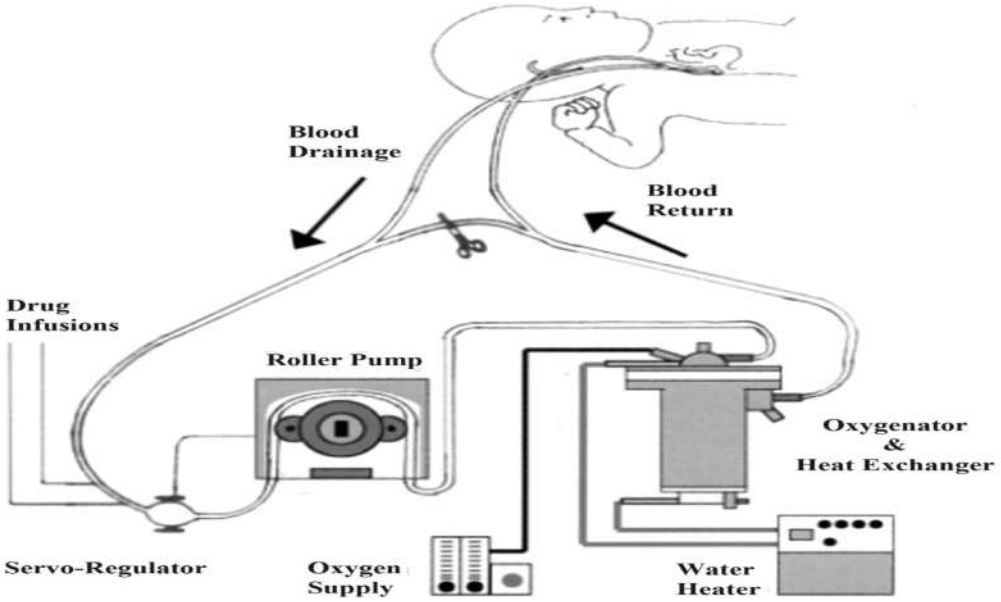

Fig. 1: ECMO circuit

The components include [Fig.1] mechanical blood pump (roller or impeller pump), gas exchange device (membrane oxygenator) and a heat exchanger. All are connected together with polyvinylchloride connecting tubing, connectors and a bladder reservoir. Wide Variety of ECMO circuits are available from simple to complex and it includes blood flow and pressure monitors, saturation monitors continuous oxyhemoglobin, circuit access sites. Blood is drained by the roller pump through the membrane oxygenator and passively drained by gravity from the venous circulation using a siphon height of 100 cm or more into a collapsible bladder. The bladder has a proximity switch to regulate the roller pump. The roller pump or centrifugal pump drain blood from the bladder and pushes it through silicone membrane then a heat exchanger before returning it to the patient. The bladder and pump are linked by a trip-switch mechanism so that if pump flow exceeds venous drainage, the bladder collapses to inhibit pump flow. Heparin is administered to the bypass circuit as systemic anticoagulation therapy, with monitoring of activated clotting time (ACT) and ACT should be maintained at 180-240 seconds.[1,3,6]

Types of ECMO circuits[1]

Circuits are broadly categorized into two types : veno-arterial (VA) and veno-venous (VV) ECMO

Table 1: Differences between veno-arterial and veno-venous extracorporeal membrane oxygenation

	Va Ecmo	V V Ecmo
Cannulation site	Vein: - Internal jugular - Femoral Artery: - Right common carotid - Axillary - Femoral - Aorta	Single cannulation - Internal jugular - Right atrium Double cannulation - Jugular–femoral - Femoro-femoral - Sapheno-saphenous
Arterial PaO2	- 60–150 mmHg 45–80 mmHg	45–80 mmHg
Indicators of O2 sufficiency	- Mixed venous oxygen saturation (mSvO2) - PaO2 - Calculated oxygen consumption	SaO2 and PaO2 - Cerebral venous saturation - Pre-membrane saturation trend
Cardiac effects	Preload: decreased Afterload: increased Pulse pressure: lower CVP: varies Coronary O2: varies - LV blood desaturated, - Cardiac Stun syndrome	May reduce RV afterload Rest unaffected
O2 delivery capacity	high	moderate
Circulatory support	Partial to complete	No direct support, increased O2 delivery to coronary and pulmonary circuit → improving cardiac output

VA: Veno-arterial, VV: Veno-venous, ECMO: Extracorporeal membrane oxygenation

Specific Care in each system when patient on ECMO[8,9]

Pulmonary System Management

Pulmonary hygiene is achieved through frequent position changes, endotracheal suctioning for every 4 hours depending on secretions along with a daily chest radiography.

Cardiovascular System Management

- Systemic perfusion and intravascular volume should be maintained.
- Monitor hourly urine output
- Assess physical signs of perfusion (temperature, capillary refill, etc)
- Monitor central venous pressure and the mean arterial blood pressure.
- Cardiac Output monitoring and can enhanced by inotropic support.

CNS Management

- Most serious and related to the degree of hypoxia and acidosis.
- Avoid paralytic agents and perform regular neurologic examinations.

- Head ultrasonography should be performed before beginning ECMO in a neonate, if possible.
- Reevaluation with daily head ultrasonography is recommended after any major events like seizures

Renal System Management

- Oliguria and acute tubular necrosis are associated with capillary leak and intravascular volume depletion during the first 24-48 hours. Diuretics are used to reduce edema if oliguria persists for 48-72 hours.
- The diuretic phase is one of the earliest signs of recovery, usually begins within 48 hours.
- Hemofiltration or hemodialysis filters may be attached to the circuit if renal failure persist.
- Hourly urine output monitoring is mandatory

Hematologic Considerations

- Maintain patient's hemoglobin level at 12-15 g/dL to optimize oxygen delivery
- Maintain platelet counts above 100,000/mcL.
- Maintain Activated clotting time (ACT) at 180-240 seconds to avoid bleeding complications

Infection Control

- Follow strict aseptic precautions.
- Obtain cultures from the circuit at least once a week to monitor the presence of infection.

Fluids, Electrolytes, and Nutrition

- Monitor fluids and electrolyte status. The patient's weight increases in the first 1-3 days on ECMO because of fluid retention.
- Hyperalimentation (eg; Total Parenteral Nutrition) techniques to meet the high-energy needs of body. Prevent air embolism by close monitoring of circuit.

Complications[3,4]

Mechanical complication

- Cannula problems
- Oxygenator failure
- Pump failure

Patient related complications

- Hemorrhagic
- Cannula/surgical site bleeding
- Hemolysis
- GI bleeding
- DIC
- Neurologic
- Cerebral infarction
- Brain death
- seizure

Cardiovascular

- Arrhythmia
- Cardiac arrest

Gastro intestinal

- Ischemic bowel

Weaning

When the patient is placed on ECMO, the pump flow is kept high to allow the heart and lungs to rest. ECMO flow (support) will be decreased as the heart and lung function begins to improve, and it enable the heart and lungs to do more work. Heart and lungs function are assessed by investigations of blood samples, chest x-rays and echocardiogram. ECMO flow is decreased as the functional status of heart and lungs have improved and the patient is tried off pump for a couple of hours.[4,6]

If during this time, the patient remains stable, ECMO can be discontinued and the patient will require full ventilation which will also be reduced once the patient improves. Once ECMO is discontinued, the catheters will be removed from the neck and the vessels will be repaired.

Conclusion

ECMO is a Mechanical devise which can support the function of Heart and lung through adequate gas exchange and perfusion. It is also used as a therapy while the damaged organs can recover or be replaced. Thorough understanding of ECMO circuit is required to manage a patient on ECMO. The indications for ECMO support have ranged from acute respiratory failure to acute cardiac failure from wide patient subsets involving neonates to adults.ECMO is an important option for the management of severe reversible causes of respiratory failure or cardiogenic shock.[6, 7, 8]

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