Extracorporeal Membrane Oxygenation

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Abstract

Extracorporeal membrane oxygenation (ECMO) is a novel technique to support patients with respiratory and/or cardiac failure. Its use is rising very fast in critical care units in our country. This article aims to give a brief overview of the technology, its uses, and the problems.

Keywords: Cardiogenic shock, Contraindications, Extracorporeal membrane oxygenation.

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Introduction

Extracorporeal membrane oxygenation (ECMO) is a technique that provides gas exchange outside the human body.[1] In other words, it is the artificial lung. The main principle of this therapy is derived from the cardiopulmonary bypass machine.[1] The technology was developed in the late 60s with the first successful extracorporeal membrane oxygenation reported in 1970.[2] The first use of this technology was for neonates with cardiorespiratory failure.[2] But soon, the technique was also used for adults with respiratory failure. Although the initial few case reports of the use of ECMO in adults were positive, a decade later, in the 1990s, as a randomized trial in adults failed to show any benefit, the enthusiasm in ECMO declined considerably.[3] But ECMO came back to the limelight again a decade-and-a-half later, with the publication of the CESAR trial in the Lancet journal, which showed that severe respiratory failure in adults did indeed benefit with the use of ECMO.[4] From then on, the use of ECMO has continued to grow astronomically in all parts of the world. The recent H1N1 epidemic, with a lot of severe respiratory failure cases, saw a significant rise in the use of ECMO. In this article, the author aim to give a brief overview of the technology, the indications, and pitfalls of ECMO.

The Technique

The ECMO setup essentially consists of a circuit and a gas exchanger.[1] Blood movement through the circuit is facilitated by a pump. The blood is pushed through a membrane in the oxygenator that allows oxygenation and CO_2 removal.[1] Then, the blood is passed through a warmer and returned to circulation.

There are mainly three types of ECMO:

- Veno arterial (VA)
- Veno venous (VV)
- Arterio venous (AV)

In VA-ECMO, the heart and lung are bypassed and most of the blood from the great veins is diverted through the circuit and returned to systemic circulation after oxygenation.

In AV-ECMO, the patient's own arterial pressure is used to drive the blood through the circuit. Thus, this is a pumpless circuit and depends on adequate cardiac pump function for proper functioning of the system. The adequacy of cardiac index must therefore be ascertained before using the AV-ECMO.

In VA-ECMO, the venous cannula is placed in the inferior vena cava and the arterial cannula is placed in either ascending aorta (central ECMO) or femoral artery (peripheral ECMO). But the problem of this circuit is that while other parts of the body may be well-oxygenated, the coronaries receive relatively a poor perfusion with the oxygenated blood. Thus, cardiac dysfunction may be aggravated.

In VV-ECMO, the blood is returned, after oxygenation, to the venous system, which subsequently goes back to the heart. Thus, this type of ECMO is used when cardiac function is relatively normal. However, the returning blood must be drained into a different vein than that used for the upstream circuit. Otherwise there will be recirculation (return of the oxygenated blood to the ECMO circuit).

The oxygenator in the ECMO circuit functions to both remove CO_2 from blood and add O_2.[5] The relative importance of the two functions depend on the type of ECMO. For example, in VV-ECMO, which is used in patients with ventilatory failure, CO_2 removal is more important than oxygenation.

The membrane across which gas exchange takes place can be made of silicone rubber, polypropylene hollow fiber, compressed surface polymethylpentene (PMP), polyvinylchloride, or polyurethane.[5] The silicone membranes require a separate heat exchanger, while the newer PMP membrane oxygenators have an inbuilt heat exchanger, thereby making the machine more compact.[5] The blood and the gas (100% O_2) flows in opposite directions, and increased gas flow increases CO_2 removal.[6] Usually the O_2 flow rate is kept twice that of circuit blood flow rate.[6] In VV-ECMO, where pulmonary support is the main issue, the ECMO flow rate is kept 50–60% of the cardiac output of the patient. In VA-ECMO, where the ECMO takes over functions of both the heart and the lungs, the flow rate is 2.1–2.5 L/minute/m^2, which will

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support the cardiac function. Just like hemodialysis, a very slow flow in the circuit should be avoided and anticoagulation is needed to prevent thrombosis.[6]

Like mechanical ventilation, ECMO is also a continuous process. It is not an intermittent process such as dialysis. Patients put on ECMO are monitored round the clock and daily tests are needed to assess clinical status. Just like mechanical ventilation, patients on ECMO will also need to be weaned. This is often a difficult decision and needs a multidisciplinary approach. First, the recovery from underlying disease is checked. Then, the ventilator settings are adjusted to acceptable levels. In general, the O_2 flow in the oxygenator is decreased and blood gases analyzed. If they are found acceptable, an ECMO-off trial can be given.

Indications[6]

ECMO is applied in cases with respiratory or cardiac failure (or both) where the underlying case is potentially reversible. According to the international registry data, still the majority of cases for which ECMO is used are in the neonatal or pediatric age group.[2] Also, according to this registry, more than 60% of cases where ECMO has been used are for respiratory failure.[2]

Pulmonary

- ARDS
- Severe pneumonia
- Post lung transplant
- Lung contusion
- Rarely in severe asthma

Cardiac

- Severe cardiogenic shock
- As a bridge to cardiac transplant
- Post cardiac transplant
- Poisoning with cardiac dysfunction
- Post cardiac surgery
- Post cardiac arrest
- Massive pulmonary embolism

Contraindications[6]

- Irreversible neurological damage
- HIV infection
- Multiple trauma with uncontrolled hemorrhage
- Terminal malignancy
- Cirrhosis with ascites
- History of recent variceal bleeding
- Old age (considered a relative contraindication)

Also, VV-ECMO cannot be done in patients with a poor cardiac output and VA-ECMO cannot be done in patients with aortic dissection, peripheral arterial disease, or severe aortic regurgitation.

Generally, VA-ECMO is better at increasing the PaO_2 than VV-ECMO. With VV-ECMO, the average PaO_2 ranges from 55 to 90 mm Hg. But with VA-ECMO, PaO_2 can be as high as 400–500 mm Hg, as the oxygenated blood is directly returned to the arterial flow.

It must be remembered that patients who are being given ECMO are also on mechanical ventilator. For acute respiratory failure, when VV-ECMO is used, the ECMO circuit mainly takes care of the CO_2 removal with some oxygenation, while some amount of oxygenation is done by the ventilator also. With ECMO, their ventilator setting improves and generally, FiO_2, PEEP, and pressure support may be decreased.

Pitfalls

- Requires a lot of trained staff round the clock
- Chance of circuit thrombosis
- Chance of infections
- Sudden circuit block may cause cardiac arrest (VA-ECMO)
- Hemolysis
- Pulmonary hemorrhage
- For the first 24–48 hours, patients on ECMO may have oliguria owing to a decreased renal flow.

Since ECMO is a critical life-support system used in most moribund of patients, the outcome statistics is difficult to analyze. Mortality and length of hospital stay often depend on the underlying condition and not just the use of ECMO. In general, pediatric patients have a better outcome than adults.[2] The outcome also depends on the timing. ARDS is one of the indication of ECMO, but if it is delayed and patients have already been on mechanical ventilation for more than 7 days, then the outcome is usually dismal.[1] Hence, decisions have to be taken early.

Indian Scenario

In India, ECMO was first started in AIIMS, New Delhi in 2001.[7] After 2008, the use of ECMO in the critical care units increased astronomically. Now, it is widely used in many advanced centres for a variety of indications from poisoning, post-transplant, ARDS, to cardiogenic shock and post cardiac surgery.[7]

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