Review Article

Extra Corporeal Membrane Oxygenation: A Lifesaving Technology

Tulza K.C.
Lecturer, Maharajgunj Nursing Campus
Correspondence: tulza.kc@hotmail.com

ABSTRACT

Extracorporeal membrane oxygenation **(**ECMO) is a mechanical circulatory support device that is used when the heart and/or lung functions are affected by severe disease or organ dysfunction. ECMO therapy provides temporary, lifesaving support to the body until surgical intervention or more permanent treatments can be provided. It may be instituted in a variety of health care settings, from the emergency room to the operating room. It has proven efficacy and is an accepted modality of care for respiratory or cardiopulmonary failure in pediatric and adult populations. Most commonly, it is instituted in an emergency or urgent situation after failure of other treatment modalities. The technology is available in few tertiary level hospitals in Kathmandu. The aim of the review is to share the lifesaving technological interventions carried out in health care settings. Nurses with specialized training are required with ratio of 1:1 or 1:2 for quality vigilant care.

Keywords: Extracorporeal membrane, Oxygenation, Extracorporeal life support

INTRODUCTION

Extracorporeal membrane oxygenation (ECMO) is a device that provides cardiac and/or respiratory support to patients with severely impaired heart and lung function for days to weeks (Trinsey, 2017; Squiers, Lima, & DiMaio, 2016). ECMO has rapidly developed and is widely used new approach for the intensive care management of acute cardiac and/or respiratory failure in adult patients including pediatrics after repair of congenital heart disease (Itagaki et al; 2014). The objective of this review is to share the new technology for life shaving to those who are critically ill. This technology is beneficial when no other form of treatment has been or is likely to be successful (Banfi et al; 2016).

Results from various clinical trials, and improvements in ECMO technology, it has been motivated its increased use in adults (Squiers et al; 2016). Although ECMO treatment procedure is in the initial phase in Nepal, many hospitals including Manmohan cardiac Center, Sahid Gangalal Heart Center, Nepal Mediciti Hospital are providing ECMO services both to adults and pediatric clients.

Even though ECMO is not a disease treatment, it provides additional time to allow for recovery from existing lung and/or cardiac disease (Yeh et al; 2018). It has revolutionized treatment of severe isolated or combined failure of lung and heart (Napp et al; 2016). It is a simplified form of cardiopulmonary bypass that is used as a bridge to organ recovery, transplantation, or further mechanical circulatory support such as a ventricular assist device (Trinsey, 2017; Napp et al; 2016). Depending on its circuit configuration, ECMO can be used to provide oxygenation, carbon dioxide removal, and/or perfusion support for days to weeks (Makdisi & Wang, 2015).For this, blood is drained from the vascular system, circulated outside the body by a mechanical pump, and then re-infused into the circulation (Lindholm, 2018).

ECMO therapy is often associated with poor outcomes and survival rates; however, in recent years, improved technology and patient management have shown that it is beneficial (Yeh et al; 2018). In every case it is important to consider that ECMO requires a multidisciplinary and experienced team to limit the potential hazards of initiation, maintenance and weaning of ECMO (Makdisi & Wang, 2015; Napp et al; 2016). This article will further discuss types, indications, complications of ECMO on clinical outcomes and major nursing responsibilities.

TYPES AND INDICATIONS

Veno-arterial ECMO (VA ECMO): It provides complete cardio respiratory support by extracting blood from the right atrium and return it to the arterial system, therefore it bypass the heart and lungs (Hayeset al; 2013). It functions as a parallel circuit to the patient's heart and lung which perform the analogous functions in all humans (Jayaraman et al; 2017). It primarily provides hemodynamic support in case of cardiogenic shock, while the effect on oxygenation depends on arterial and venous cannulation sites, the patient's cardiac output and respiratory function (Napp et al; 2016). This is indicated in post-cardiotomy, post-heart transplant and in severe cardiac failure due to almost any other cause (e.g. cardiomyopathy, myocarditis, acute coronary syndrome with cardiogenic shock) {Makdisi & Wang, 2015}.

Veno-Venous ECMO (VV ECMO): The VV ECMO circuit drains venous blood then oxygenated and pump back into the same venous compartment (Lindholm, 2018). Here, blood is percutaneous drained via a cannula from the right atrium, or superior vena cava and inferior vena cava, and oxygenated and decarboxylated in a oxygenator device and returned via a second cannula to the right atrium. By this way, pre- oxygenated blood enters the pulmonary circuit and provides systemic oxygenation (Napp et al; 2016). The main indications for VV ECMO are a reversible respiratory failure (Rupprecht et al; 2015)including acute respiratory distress syndrome (ARDS) either due to broncho-pulmonary aspiration, bacterial, viral or atypical pneumonia, barotraumas or acute or chronic interstitial pneumonitis (Banfi et al; 2016).

Characteristically, VA ECMO is used for cardiac or combined cardiopulmonary failure, and VV ECMO is used for respiratory failure (Hayes et al; 2013). The major difference between VA and VV ECMO circuits is the types of cannulae and location of their insertion (Squiers et al; 2016).

The proper placement of one or two cannula is a prerequisite for ECMO therapy. Even if there is no defined technical gold standard for cannula placement, perfect cannulation usually means safe puncture of the correct vessel, insertion of the cannula without vessel laceration and adequate cannula fixation under ultrasonic guidance (Rupprecht, 2015). Typically, for average adults, the arterial (outflow) cannula is a short 15–20 French (Fr) catheter placed in the femoral artery with the tip in the common iliac artery and the venous (inflow) cannula is at least 21Fr (Rupprecht, 2015; Jayaraman et al; 2017).

COMPLICATIONS OF ECMO ON CLINICAL OUTCOMES

Although ECMO can improve survival of patients with advanced heart and respiratory diseases, there is significant associated morbidity with performance of this intervention (Cheng et al; 2014). Complications can arise from patient factors or malfunctions of ECMO circuit components as mentioned in reports(Mosier et al; 2015, Aubron et al; 2013; and Cheng et al; 2014). Thus, appropriate patient selection is critical for successful ECMO outcomes.

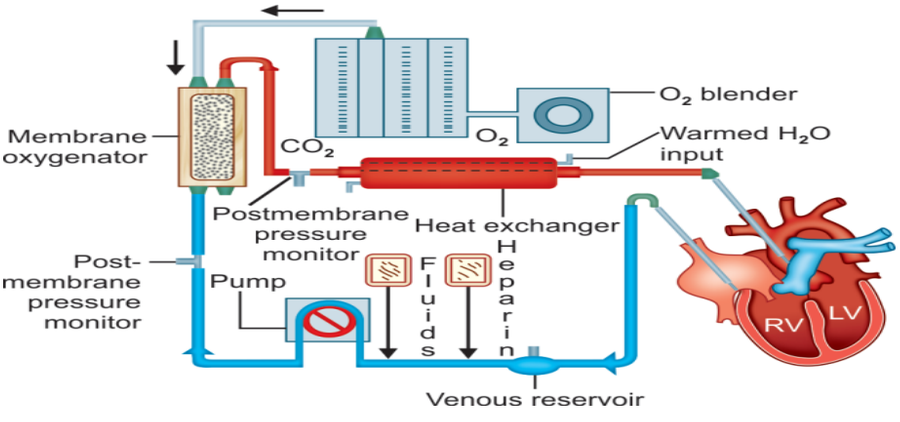

Fig: The ECMO system

Patient Factor	ECMO circuit Factor
Hemorrhage (30–40%), stroke, thrombosis, and infection (31%) related to anti-coagulation therapy, and indwelling lines/tubes. .	Gas embolism, Massive blood loss secondary to tubing ruptures or disconnections.
Hemolysis, pulmonary edema, neurologic complications and long-term neuro-cognitive abnormalities (50%), and lower extremity ischemia from occlusion of the arterial flow with placement of the arterial cannula.	Blood clots, loss of circuit flow and primary failure of circuit components (Squiers et al; 2016).
Long-term complications include neurologic injury and neuro-cognitive abnormalities (50%) (Aubron et al; 2013; Cheng et al; 2014; Mosier et al; 2015)	

NURSES' MAJOR RESPONSIBILITIES

ECMO is a complex treatment that requires diligent nursing care around the clock. A recent expert consensus suggests nurses-to-EMCO patient ratios should be at least1:1 or 1:2 to deliver safe and quality patient care (Botsch et al; 2019). Critical care nurses with the knowledge and ability to identify complications of ECMO can potentially reduce morbidity and mortality in these high-acuity patients (Bergeron & Holifield, 2020). Close collaboration between care providers is crucial, particularly between the nurses managing hemodynamic medication infusions and the ECMO specialist managing the pump. Nurses provide extensive, holistic care for ICU patients and their families, which require additional specialized training. Major nursing care should include monitoring of the ECMO circuits, assessment for erythema, circulation, infection and dressing integrity in the cannula insertion sites, skin care, care of pressure areas, and supporting in early physical rehabilitation and mobility, detection and prevention of systemic complications related to ECMO (Botsch et al; 2019).

SUMMARY

Extracorporeal membrane oxygenation provides support for patients with respiratory, cardiac, or combined cardiopulmonary failure. It is the treatment of choice for patients with respiratory or cardiac failure refractory to optimal mechanical ventilation and conventional medical treatments. Special consideration should be given to clients with regard to anatomy, physiology, cannulation, and circuit management. Properly trained staffs team in ECMO management is a crucial determinant of survival for patients. Nevertheless, ECMO is an invasive life support system, with substantial risk of adverse events like bleeding, vascular complications, thromboembolic events and infections.

REFERENCES

Aubron, C., Cheng, A.C., Pilcher, D., Leong, T., Magrin, G., Cooper, D.J., Scheinkestel, C., & Pellegrino, V.(2013). Factors associated with outcomes of patients on extracorporeal membrane oxygenation support: a 5-year cohort study. Critical Care, 17: R73.

Banfi, C., Pozzi, M., Siegenthaler, N., Brunner, M.E., Tassaux, D., Obadia, J.F., Bendjelid, K., & Giraud, R. (2016).Veno-venous extracorporeal membrane oxygenation: cannulation techniques. Journal of Thoracic Disease, 8(12): 3762–3773.

Baran, D.A. (2017). Extracorporeal Membrane Oxygenation (ECMO) and the Critical Cardiac Patient. Current transplantation reports, 4(3): 218–225.

Bergeron, A., & Holifield, L. (2020). Extracorporeal Membrane Oxygenation: The nurses role in patient care. Critical Care, 15 (3): 6-14

Botsch, A., Protain, E., Smith, A.R., & Szilagy, R. (2019). Nursing Implications in the

ECMO Patient. Advanced Application in Extracorporeal Membrane Oxygenation. http://dx.doi.org/10.5772/intechopen.85982

Cheng, R., Hachamovitch, R., Kittleson, M., Patel, J., Arabia, F., Moriguchi, J., Esmailian. F., & Azarbal, B. (2014). Complications of Extracorporeal Membrane Oxygenation for Treatment of Cardiogenic Shock and Cardiac Arrest: A Meta-Analysis of 1,866 Adult Patients. Annals of Thoracic Surgery, 97:610–6.

Hayes, D., Tobias, J.D., Kukreja, J., Preston, T.J., Yates, A.R., Kirkby, S., &Whiston, B.A. (2013). Extracorporeal life support for acute respiratory distress syndromes. Ann Thorac Med, 8(3): 133–141.doi: 10.4103/1817-1737.114290

Itagaki, T., Onodera, M., Okuda, N., Nakataki, E., Imanaka, H., & Nishimura, M. (2014). Successful use of extracorporeal membrane oxygenation in the reversal of cardiorespiratory failure induced by atonic uterine bleeding: a case report. Journal of medical case reports, 8:23.

Jayaraman, A.L., Cormican, D., Shah, P., & Ramakrishna, H. (2017). Cannulation Strategies in Adult Veno-arterial and Veno-venous Extracorporeal Membrane Oxygenation: Techniques, Limitations, and Special Considerations. Ann Card Anaesth, 20(1): S11–S18. doi: 10.4103/0971-9784.197791

Lindholm, J.A. (2018). Cannulation for veno-venous extracorporeal membrane oxygenation. J Thorac Dis, 10 (5): S606–S612. doi: 10.21037/jtd.2018.03.101

Makdisi, G., & Wang, I. (2015). Extra Corporeal Membrane Oxygenation (ECMO) review of a lifesaving technology. Journal of Thoracic Disease, 7(7): E166-E176.

Mosier, J.M., Kelsey, M., Raz, Y., Gunnerson, K.J., Meyer, R., Hypes, C.D., Malo, J., Whitmore, S.P., & Spaite, D.W. (2015). Extracorporeal membrane oxygenation (ECMO) for critically ill adults in the emergency department: history, current applications, and future directions. Critical Care, 19.

Napp, L.C., Kuhn, C., Hoeper, M.M., Vogel-Claussen, J., Haverich, A., Schafer, A &Bauersachs, J. (2016). Cannulation strategies for percutaneousextracorporeal membrane oxygenation in adults. Clin Res Cardiol, 105: 283–296. doi: 10.1007/s00392-015-0941-1

Rupprecht, L., Lunz, D., Philipp, A., Lubnow, M., & Schmid, C. (2015). Pitfalls in percutaneous ECMO cannulation. Heart, Lung and Vessels, 7(4):320-326.

Sharma,A., Pokharel, J.N., Murari Raj Upreti, M.R., Koirala, B., Sharma , J., Pradhan, S., &Bhatta, M.(2014). Initial experience with extracorporeal membrane oxygenation following cardiac surgery in children with congenital heart disease. Nepalese Heart Journal,11(1): 39-44

Squiers, J. J., Lima, B., & DiMaio, J. M. (2016). Contemporary extracorporeal membrane oxygenation therapy in adults: Fundamental principles and systematic review of the evidence. The Journal of Thoracic and Cardiovascular Surgery, 152(1), 20–32. doi:10.1016/j.jtcvs.2016.02.067

Trinsey, A. (2017). Extracorporeal membrane oxygenation: A review. Nursing Critical Care, 12(4): 16-23.

Yeh, T.C., Chang, H.H., Ger LP, S., Wang, J.O., Kao, S., Ho, S.T. (2018). Clinical risk factors of extracorporeal membrane oxygenation support in older adults. PLOS ONE, 13(4): e0195445.