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Extracorporeal Membrane Oxygenation—Hemostatic Complications

Deirdre A. Murphy [a,b,*], Lisen E. Hockings [a,b], Robert K. Andrews [c], Cecile Aubron [d,e], Elizabeth E. Gardiner [c], Vincent A. Pellegrino [a,b], Amanda K. Davis [f]

[a] *Department of Intensive Care and Hyperbaric Medicine, Alfred Hospital, Melbourne, Australia*
[b] *Department of Epidemiology and Preventative Medicine, School of Public Health, Monash University, Melbourne, Australia*
[c] *Australian Centre for Blood Diseases, Monash University, Melbourne, Australia*
[d] *ANZIC Research Centre, Department of Epidemiology and Preventive Medicine, Monash University, Melbourne, Australia*
[e] *Transfusion Research Unit, Department of Epidemiology and Preventive Medicine, Monash University, Melbourne, Australia*
[f] *Department of Haematology, Alfred Hospital Melbourne, Australia*

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ABSTRACT

The use of extracorporeal membrane oxygenation (ECMO) support for cardiac and respiratory failure has increased in recent years. Improvements in ECMO oxygenator and pump technologies have aided this increase in utilization. Additionally, reports of successful outcomes in supporting patients with respiratory failure during the 2009 H1N1 pandemic and reports of ECMO during cardiopulmonary resuscitation have led to increased uptake of ECMO. Patients requiring ECMO are a heterogenous group of critically ill patients with cardiac and respiratory failure. Bleeding and thrombotic complications remain a leading cause of morbidity and mortality in patients on ECMO. In this review, we describe the mechanisms and management of hemostatic, thrombotic and hemolytic complications during ECMO support.

Contents

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* Corresponding author. Deirdre Murphy, MBBChBAO, Department of Intensive Care, Alfred Hospital, 3rd Floor, East Block, PO Box 315, Prahran, Victoria 3188, Australia.
E-mail address: d.murphy@alfred.org.au (D.A. Murphy).

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The first case report of successful extracorporeal membrane oxygenation (ECMO) for respiratory failure was published by Hill and colleagues [1] in 1972. Since that time, there has been considerable interest in its role as supportive therapy for patients with life-threatening cardiac and/or respiratory failure. The role of ECMO in the neonatal population has been clearly established [2–4], and a growing acceptance of ECMO in the adult population has occurred despite a lack of convincing randomized controlled trial evidence to support its use [5–8]. This expanding role has occurred in the context of advances in membrane oxygenator and pump technology, the 2009 H1N1 influenza pandemic and interest in the use of temporary mechanical circulatory support, particularly in patients in refractory cardiac arrest [7–15]. Hemostatic complications, both bleeding and thrombosis, remain the leading causes of morbidity and mortality in patients treated with ECMO [11,16–19]. Hematologists and transfusion specialists are increasingly being asked to help navigate the complexities of thrombotic and hemorrhagic risks that occur when blood is exposed to the extracorporeal circuit. Here, we review the current literature around the utility of ECMO with special focus on hemostatic complications commonly found in patients receiving ECMO support and include some suggested strategies to manage such hemostatic complications.

Mode of ECMO Support

The mode of ECMO is defined by the location of the access and return cannulae. ECMO involves accessing deoxygenated venous blood from the systemic circulation, pressurizing it using a pump, passing it through a membrane oxygenator and then returning it to either the venous side of the circulation (the right atrium) in venovenous ECMO (VV ECMO or respiratory ECMO), or to the arterial circulation (typically the aorta) in venoarterial ECMO (VA ECMO or cardiac ECMO). Pumpless arteriovenous configurations exist but tend to provide more carbon dioxide (CO_2) removal than oxygenation (extracorporeal CO_2 removal). They provide minimal oxygenation support and no cardiovascular support and will not be specifically addressed in this discussion.

VV ECMO

Indications

VV ECMO is currently indicated for potentially reversible, life-threatening respiratory failure where conventional ventilatory strategies are failing and where native cardiac function is adequate (VV ECMO provides no direct circulatory support) (Fig 1). There is growing interest in the role of ECMO in patients with chronic respiratory failure, particularly as a bridge to lung transplantation [20–22].

VA ECMO

VA ECMO is used to support patients with inadequate cardiac output and patients with combined cardiac and respiratory failure. VA ECMO can be either central or peripheral. The decision to use central or peripheral ECMO can be institution or patient specific.

Central VA ECMO

Cannulae are inserted directly via a sternotomy—with venous access into the right atrium and arterial return into the proximal aorta. This ensures oxygenation of the arterial supply to the coronary and the cerebral circulations (the most proximal branches of the aorta). Central VA ECMO can support patients with both cardiac and respiratory failure (Fig 2).

Peripheral VA ECMO

Cannulae are inserted into the cavae via the femoral or jugular vein approach. The return cannula is classically placed in the distal aorta via the femoral artery. Insertion may be percutaneous or open. A distal perfusion cannula is recommended to supply the limb distal to the return cannula (Fig 3). More recently, the subclavian artery has been described as an alternative return site.

Indications

Venoarterial ECMO is currently indicated for potentially reversible cardiogenic shock (bridge to recovery), or as a bridge to more definitive long-term cardiovascular support in patients who are suitable for ventricular assist device (VAD) or heart transplantation. Where the suitability or need for long-term support is unclear, VA ECMO may be used as a bridge to decision. Venoarterial ECMO as an adjunct to cardiopulmonary resuscitation (ECMO-CPR, or E-CPR) is emerging as a viable option in select patients who are refractory to conventional CPR [13–15].

Membrane Oxygenators

Improvements in membrane oxygenators have facilitated the increased use of ECMO support in recent years. Current oxygenators consist of multiple polymethylpentene hollow microfibers that are permeable to gas but not liquid. They provide a very efficient surface for gas exchange with no direct blood–gas interaction. In contrast to previous generations of oxygenators designed for short-term use in cardiopulmonary bypass, they have a low priming volume and a low resistance to blood flow that has enabled the use of centrifugal rather than roller blood pumps. In addition, they are resistant to plasma leak (as occurs in microporous gas exchange membranes), allow the potential for thromboresistant coatings and have been associated with reduced clotting factor and platelet transfusion requirements [10,23–27].

Blood Pumps

Both displacement (roller) and rotary (centrifugal and diagonal) pumps have been used for ECMO as well as cardiopulmonary bypass (CPB). With the advent of lower resistance oxygenators, centrifugal pumps have been employed more widely. They have the advantages