Extracorporeal membrane oxygenation: a trauma surgeon’s perspective

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Received: 1 June 2013; Accepted: 21 June 2013; Published: 13 August 2013

Extracorporeal membrane oxygenation (ECMO) as a form of prolonged life support revolutionized the care of fulminant respiratory failure after being popularized in the 1970s. Indeed, it has become standard treatment of neonatal respiratory failure. Since that time, we have seen the body of evidence and the practice of ECMO expand to treat acute lung injury (ALI) and adult respiratory distress syndrome (ARDS), with some centers reporting remarkable success.

The use of ECMO for trauma patients, however, has been approached with trepidation by many practitioners due to the lack of experience with the technique and concerns for complications. Reports of ECMO utilization in the trauma population resurfaced in the 1990s (1), and most of the known literature is comprised of case reports or case series (1–7). Though a level-one trauma center, our experience rarely includes cases of such severity as those detailed in the case reports: our experience has seen ECMO used in the context of the medically critical-ill, or in the post-cardiac surgery arena. From our standpoint as trauma care providers, there are a series of questions to be developed and answered before our adoption of ECMO as a reliable rescue strategy. Some of these factors include: the addressing of hemorrhagic complications, characterizing the interplay between ECMO and traumatic brain injury (TBI) (not limited to intracranial hemorrhage), appropriate timing and administration (e.g. defining the role for veno-venous (VV) versus veno-arterial (VA) as well as cannulation site selection), and site resources and transportation issues.

First, ECMO is a cost- and labor-intensive undertaking. We believe that further information is required before the determination of the best balance of outcomes versus resource utilization. However, it is commonly accepted that appropriate patient selection is important. In current practice, ECMO remains a ‘rescue’ strategy reserved for those who fail both standard and advanced [e.g. high-frequency oscillatory ventilation (HFOV), airway pressure release ventilation (APRV)] ventilatory methods. The indications for the initiation of ECMO as outlined by the Extracorporeal Life Support Organization (ELSO) are severe hypoxemia/hypercarbia and anticipated >80% mortality with conventional ventilation strategies. Notably, there are no outlined contraindications to ECMO: ‘…each patient is considered individually with respect to risks and benefits’. That being said, ECMO should be approached with caution in ‘the aged, those with significant medical comorbidities, and those with recent intracranial hemorrhage’ (8).

In addition to the importance of patient selection, it also appears as though the best outcomes occur in centers that have experienced, dedicated ECMO/perfusion teams. The ELSO Guidelines identify ideal characteristics of ECMO-providing centers as those, ‘located in geographic areas that can support a minimum of six ECMO patients per center per year. The cost effectiveness of providing fewer than six cases per year combined with the loss, or lack of clinical expertise associated with treating fewer than this number of patients per year should be taken into account when developing a new program’ (9). At present, there is a relatively limited number of centers that have both the traumatic volume and ECMO expertise to sustain research options. Further frustrating consolidations are the logistic considerations that limit patient access: the most ill patients are the most at risk during transportation to these established ECMO centers. A way to consolidate the data/patient care would be to encourage awareness in the surgical community of ECMO as a therapeutic option in the trauma population.

We note that the current practice of ECMO still sees hemorrhagic complications as the most frequently occurring adverse events (primarily at cannulation and recent operative sites) (10). Due to the risk of bleeding, hemorrhagic shock and TBI have been regarded as contraindications to the use of ECMO: both situations are not infrequently encountered in the trauma population.
Factors contributing to the hemorrhagic risk of ECMO include the device/tubing in addition to the requirement of systemic anticoagulation. The ECMO circuit is a foreign body and platelets are consumed in the passage of blood through the tubing. Despite significant advances in the materials with which the components are constructed (11), the concerns for subsequent hemorrhage and issues associated with blood product replacement remain.

At the same time, the passage of blood through the foreign body is also thrombogenic. Thrombosis in the circuit consumes platelets and clotting factors and can result in a syndrome similar to disseminated intravascular coagulation (DIC) (12). To prevent catastrophic thrombotic events, it is recommended that patients be maintained with an activated clotting time (ACT) 1.5 times normal with systemic unfractionated heparinization. While there are reports of PTTs of 110–140 seconds being used without adverse events (3), the determination of a ‘safe’ level of anticoagulation and its timing is worthy of investigation. Heparin-coated circuitry may decrease the need for systemic anticoagulation, and the use of centrifugal-type pumps may minimize the mechanical hemolysis (3). Equally important is recognizing that patients exposed to heparin may develop heparin-induced thrombocytopenia + thrombosis (10).

Another area of significant concern is the interplay between ECMO and TBI and not simply limited to the hemorrhagic aspect. We know that the magnitude of secondary brain injury is not only impacted by oxygenation, perfusion, and intracranial pressure, but also by the inflammatory response (12). Extracorporeal circulation is associated with a number of immunologic/inflammatory changes; understanding the impact on TBI would need to be established. These circulating factors are difficult to quantify and cannot be assessed by imaging modalities or intracranial pressure monitors. It stands to reason that TBI patients could potentially benefit from the use of ECMO in refractory hypoxemia resulting from ALI/ARDS: we would expect a benefit from VA ECMO as it should liberate patients from vasoactive medications (pressors) improving cerebral vasoconstriction and hypoxia (secondary injury), but the data remains to be elucidated.

Another topic of interest in the traumaically injured would be the method of cannulation and ECMO delivery. VV ECMO is used primarily for cases of hypoxemia in the absence of cardiac dysfunction, whereas VA circuits serve as a form of cardiopulmonary bypass. It is proposed that the preferential use of VA ECMO may ‘enable the restricted and congested heart to recover by unloading the right atrium and ventricle’ (3), regardless of the presence or absence of cardiac dysfunction at the initiation of therapy. While an interesting concept, there are discrete limitations to the practice of VA ECMO. First, the use of either the femoral or carotid artery is required. Femoral artery use leads to distal ischemia in 20% of cases, requiring alternative means of distal perfusion (e.g. antegrade superficial femoral artery cannulation and perfusion). Carotid artery use requires ligating the carotid, interrupting cranial blood flow. The ensuing concern would be the resulting derangement of cerebral perfusion exacerbating traumatic brain-secondary injury. It would potentially benefit our polytrauma patients to understand the best method of administering ECMO, as well as identify the safest location of access.

The use of extracorporeal life support in the injured critically ill remains an interesting therapeutic option/area of study. As practices and equipment continue to improve, and with a strong focus on ethical application, we hope to embrace ECMO as a meaningful/worthwhile expenditure of resources for our trauma patients.

References