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ECMO in trauma patients: Future may not be bleak after all!

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In the USA, trauma represents the leading cause of death between the ages of 1 and 46 years and contributed to 192,000 deaths in 2014.[1] Major trauma is also responsible for significant disabilities and increased hospital length of stay (LOS), and represents a huge financial burden.

Acute respiratory failure (ARF) is multifactorial in trauma patients with diverse underlying pathophysiological mechanisms. In a blunt thoracic injury, all the chest compartments can be affected and are directly responsible for mortality of 20–25%.[2] Two main mechanisms contribute to pulmonary injury; the first mechanism is a direct trauma leading to contusion, intra-alveolar hemorrhage, and aspiration pneumonia. Some of the mechanical injuries to the chest (pneumothorax, hemothorax, airways injury) are reversible by various interventions (pleural drains, surgical airway repair, etc.). The second mechanism is an indirect immunological lung injury, which may result from extrapulmonary trauma and/or the required management of trauma patients (massive transfusion, fluid overload, ventilator lung induced injury, etc.) leading to acute respiratory distress syndrome (ARDS).

Extracorporeal membrane oxygenation (ECMO) is an attractive therapy in ARF. In 1972, the first successful use of ECMO was in a 24-year-old polytrauma patient who developed a "shock lung syndrome".[3] However, subsequent results in the next two to three decades were disappointing. The H1N1 influenza epidemic with a high number of young patients with severe respiratory failure led to resurgence of ECMO use. ECMO has been successfully used in severe ARDS secondary to the influenza A (H1N1) epidemic in 2009 with acceptable outcomes. A large multicenter trial (CESAR trial) in the UK showed that referral and transfer of patients to severe respiratory failure centers with ECMO capabilities reduced mortality in severe ARDS patients.[4] Despite these encouraging

results and use of ECMO worldwide for severe ARDS, use of ECMO in trauma patient is poorly studied. Severe ARF requiring mechanical ventilation (MV) in trauma patients is associated with high mortality and increased hospital LOS. In patients with severe impaired gas exchange despite optimized MV, ECMO is proposed to avoid injurious lung ventilation. It is prudent to start ECMO at an earlier stage to avoid irreversible MV-induced pulmonary injury in these cases. In severe thoracic trauma cases requiring lung resection or progressive lung fibrosis with severely limited reserve, ECMO may prove to be the main therapy as a bridge to lung transplant. The heterogeneity and complexity of trauma patients make ECMO use challenging in trauma cases with uncertain benefit/risk balance and multidisciplinary decision-making becomes extremely important on a case-by-case basis.

Among trauma patients with ARF, those with a traumatic brain injury represent a specific group as their prognosis is mainly dependent on neurological recovery. These patients may require earlier ECMO support compared with non-brain-injured patients, to prevent secondary neurological injury from severe hypoxemia, hypercapnic acidosis, and worsening cerebral edema from fluid overload. Indeed, the combination of gas exchange alteration from respiratory failure and intracerebral pathology leads to a difficult challenge in ventilatory management of these patients. The usual dilemma of lung-protective versus neuroprotective ventilation creates contradictory goals. A high PEEP strategy, permissive hypercapnia, and permissive hypoxemia are well-accepted strategies for ARDS management, but may lead to secondary neurological insult in brain-injured patients. Munoz-Bendix and colleagues showed in their study that intracerebral pressure can be decreased by the $PaCO_2$ control with ECMO support in trauma patients, which is a major goal of neuroprotective ventilation in these patients.[5] ECMO in brain-injured patient is an attractive option as it allows the combination of neuroprotective and lung-protective ventilator strategies at the same time. The goal of ECMO is to support the patients who have good functional prognosis from their neurological injury. Unfortunately, this prognostication is not easy in brain-injured patients at the time when they are in need of ECMO. Better prognostic predictors in brain-injured patients may help the healthcare teams to improve the selection of patients who will benefit from ECMO.

ECMO use is limited in trauma patients, particularly those with traumatic brain injury, complicated pelvic fractures, or major vascular injuries in view of fear of serious bleeding during systemic anticoagulation. However, with improved ECMO circuit technology (newer pump systems, reduced circuit area, newer biocompatible circuit material, heparin coating etc.), and a relatively high blood flow during veno-venous (VV) ECMO, thrombotic complications during heparin-free ECMO runs are relatively uncommon. In the literature, there are many reports of prolonged heparin-free ECMO use in patients with trauma as well as other pathologies with high risk of bleeding complications with excellent outcomes and no serious thrombotic complications.[6–9]

Recently, a systematic review of the literature with an aggregated total of 215 trauma patients showed an overall survival to discharge ranging from 50 to 79%;[10] however, this work suffered from various limitations. All studies included were retrospective and included a maximum of five patients per year per center. Most of the studies with a high number of patients were performed over many years making definitive conclusions difficult to formulate as the ECMO management and techniques and ICU approaches have evolved over the years.

An interesting cohort study using data from two American centers compared 76 trauma patients on MV and 26 who required VV extracorporeal life support (ECLS).[11] There were no differences between the two groups regarding ventilator days, intensive care unit LOS, and hospital LOS. However, when ECLS patients were severity matched to patients on MV, a better survival was demonstrated in the ECLS group. These are very encouraging results, but there were multiple limitations, and lot of questions remained unanswered. Further studies are needed to define the appropriate time to initiate ECMO, proper patient selection, and outcome data beyond survival to hospital discharge, including functional and psychosocial outcomes, particularly in brain-injured patients.

The holy grail of ECMO use in trauma patients is the optimal timing to initiate this therapy. ECMO is a complex treatment modality, which involves a multiprofessional team of clinicians, and financial and physical resources for its optimal implementation. The use of ECMO in inappropriate patient at an inappropriate time may lead to poor outcomes with wastage of precious healthcare resources.

Unfortunately, several large ECMO centers do not have a level 3 trauma center and, at the same time, multiple trauma centers do not have any ECMO service. Therefore, studies from centers with combined trauma and ECMO services are really needed to demonstrate their complementary positive impact on the care of trauma patients.

Trauma patients should be considered as a genuine group to benefit from ECMO support. Beside the encouragement of centers to publish their individual experiences, a multidisciplinary task force under the aegis of ELSO may be a reasonable approach to conduct studies to answer the unresolved questions of ECMO use in trauma patients.

A reasonable first phase towards this goal would be to create a specific registry for interested centers with experience in trauma care as well as ECMO capabilities. The management of these patients is complex and needs a multidisciplinary team approach with experience of trauma teams as well as intensivists and an ECMO team with a reasonable patient volume. The specific pathways created by collaboration of ECMO specialists, perfusionists, intensivists, emergency room physicians, trauma surgeons, and interventional radiologists will lead to improved patient care as well as valuable data to optimize the care of these patients in the future.

The time has come not to deny the lifesaving ECMO therapy to trauma patient based on our perceived notions and prejudices. Indeed, the decision to start ECMO in trauma patients is not easy and straightforward and needs input from multidisciplinary team members but should be considered for each patient on an individual basis and may lead to very satisfying outcome in these mostly young patients. The need for more data and more outcome-based well-designed studies are needed to better define the role of ECMO in the care of trauma patients. The ECMO community should work in harmony to achieve this goal. The future of ECMO in trauma patients may prove to be bright after all.

Keywords: ECMO, trauma, brain injury, multidisciplinary team

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