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Review

Extracorporeal life support in polytraumatized patients

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HIGHLIGHTS

- In polytrauma patients, cardiovascular shock and pulmonary failure are leading death causes.
- Extracorporeal life support (ECLS) is effective in treating shock status and pulmonary failure.
- Improvements in devices and materials biocompatibility have made ECLS safer and easier in polytrauma.
- Advanced management of polytrauma patients should include ECLS.

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ABSTRACT

Major trauma is a leading cause of death, particularly amongst young patients. Conventional therapies for post-traumatic cardiovascular shock and acute pulmonary failure may sometimes be insufficient and even dangerous.

New approaches to trauma care and novel salvage techniques are necessary to improve outcomes. Extracorporeal life support (ECLS) has proven to be effective in acute cardiopulmonary failure from different etiologies, particularly when conventional therapies fail.

Since 2008 we have used ECLS as a rescue therapy in severe poly-trauma patients with refractory clinical setting (cardiogenic shock, cardiac arrest, and/or pulmonary failure). The rationale for using ECLS in trauma patients is to support cardiopulmonary function, providing adequate systemic perfusion and, therefore, avoiding consequent multi-organ failure and permitting organ recovery. From our data ECLS, utilizing heparin-coated support to avoid systemic anticoagulation, is a valuable option to support severely injured patients when conventional therapies are insufficient. It is safe, feasible, and effective in providing hemodynamic support and blood-gas exchange.

Moreover, we have identified several pre-ECLS patient characteristics useful in predicting ECLS treatment appropriateness in severe poly-traumatized patients. These might be helpful in deciding whether the ECLS should be initiated in patients who are severely complex and compromised.

Future improvements in materials and techniques are expected to make ECLS even easier and safer to manage, leading to a further extension of its use in severely injured patients.

1. Background

Major trauma is a leading cause of death, particularly amongst young patients, causing more than 5 million deaths every year worldwide [1,2].

Conventional therapies for post-traumatic cardiovascular shock and acute pulmonary failure may sometimes be insufficient and even dangerous [3–7].

New approaches in trauma care and advanced treatments are needed to modify the actual therapeutic strategy and treatment protocols. Extracorporeal life support (ECLS) has proven to be effective in shock (in venous-arterial modality, VA-ECLS) and pulmonary failure (in venous–venous modality, VV-ECLS or ECMO), when standard therapies have failed [7,8].

However, the need for anticoagulation has historically limited of the use of ECLS in polytrauma patients because of the increased risk of bleeding. Since the first use of ECLS in a trauma victim, performed by Donald Hill in 1972 [9], many changes and improvements in devices and materials biocompatibility have made the deployment of ECLS safer and easier, even in complex and polytraumatized patients [7–10]. Paradoxically, there is a possible

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advantage in using VA-ECLS to control venous hemorrhage, by reducing central venous pressure [10].

Since 2008 we have applied ECLS as rescue therapy in severe trauma patients with refractory cardiogenic shock, cardiac arrest, and/or pulmonary failure [11]. As others have reported [4,7–10,12–19], the rationale for using ECLS in trauma patients is to treat refractory pulmonary and cardiopulmonary failure, providing adequate systemic perfusion, avoiding consequent multi organ failure and permitting organ recovery. Furthermore, we have identified several patient characteristics to be used as predictors of the ECLS treatment's appropriateness [14,15].

2. Is ECLS feasible in trauma patients?

Despite Hill's successful experience in 1972 (Fig. 1), the use of ECLS for trauma patients, has had inconsistent and unrewarding results due to the lack of experience with the technique, poor biocompatibility of devices, and a high incidence of complications [2–4,8,9].

In the 1990s, interest in ECLS utilization in trauma patients returned (8), with accumulating experience and improvements in material biocompatibility, specifically the development of ECLS circuit with heparin coating and high-flow percutaneous cannulae.

In 1999, The University of Michigan group published a series of 30 patients with ARDS following trauma for which ECLS was utilized [16]. Based upon previous data, they expected a survival rate of less than 20% in these patients, yet 50% survived. This survival rate was consistent with that reported by Perchinsky et al. a few years earlier in a smaller case series [16,17].

Despite these improved results, there was reluctance to adopt ECLS as a standard rescue strategy in polytraumatized patients due to uncertainties regarding cannulation modality, anticoagulation initiation and level, and especially the interplay between ECLS and traumatic brain injury.

However, in recent years, multiple case reports have reported successful use of ECLS even in the presence of traumatic brain injury, demonstrating that ECLS is well tolerated without anticoagulation for several hours [18,19].

Appropriate patient selection is important, and in current practice, ECLS remains a ‘rescue’ strategy reserved for those who fail both standard and advanced therapy for cardiopulmonary failure, and it also appears as though the best outcomes occur in centers that have experienced, dedicated ECLS teams [8].

2.1. Surgical technique and strategy

Currently, in our experience, ECLS has been employed in 20 adult polytrauma patients (mean age 44.2 ± 16,2 years [range 15–69], mean Injury Severity Score 53.6 ± 17.2 [range 18–75]) for refractory cardiopulmonary failure. To date this is the largest series reported in literature [4,7,9,11–19].

Usually, in the polytrauma patient, the indication for VA-ECLS is cardiopulmonary failure with shock or post-traumatic cardiac arrest refractory to conventional resuscitative treatment; for VV-ECLS the indication is post-traumatic respiratory insufficiency with severe hypoxemia (PaO_2/FiO_2 ratio of less than 100) or hypercapnic acidosis refractory to conventional mechanical ventilation.

In all our cases, peripheral percutaneous cannulation was utilized. Transthoracic/transesophageal ultrasonography was used to guide insertion and to evaluate cannula position and definitive setting [20].

In VA-ECLS cases, we adopted the femoro-femoral configuration. To prevent leg ischemia, a small shunt cannula (8–10 Fr) was inserted in the femoral artery, distal to the ECLS cannula (Fig. 2A). In VV-ECLS (Fig. 2B), we used two cannulas as femoro-jugular setting, or a single bi-lumen cannula (jugular access) [21].

2.1.1. ECLS circuit and cannulas

The circuit used is “tip-to-tip” heparin coated, thus reducing the level of systemic anticoagulation and thromboembolic risk, and includes a special intake stopcock for large volume administration. A heat exchanger device is integrated into the ECLS circuit to restore and maintain the patient's temperature. These features are particularly important in polytraumatized patients [4,7–11,13,16,17,19].

2.1.2. Polytraumatized patient on ECLS, management and weaning

In polytraumatized patients, due to actual or potential bleeding risk we [11], as other authors [4,18,19] initially perform heparin-free extracorporeal support until bleeding has stopped and normalization of patient coagulative status is achieved. In our case series, heparin administration was started at a mean time of 18.3 ± 19.4 [range 2.5–72] hours after ECLS deployment, and titrated by bedside measurement of activated partial thromboplastin time (aPTT, target value: 40–50 s) every 2 h. Activated recombinant factor VII (rFVIIa)

Fig. 1. First successful ECLS patient. The first successful extracorporeal life support patient, treated by J. Donald Hill using the Bramson oxygenator (foreground), Santa Barbara, 1971. The ECLS indication was “shock lung” due to polytrauma succeeding a motorcycle crash. The 24-year-old man was supported for 75 h.