Abstract:
The primary cause of death in patients with severe poisonings is cardiopulmonary failure. Meticulous supportive care remains the mainstay of treatment. However, early aggressive hemodynamic support with extracorporeal life support (ECLS) can be beneficial in patients with severe refractory toxin-induced shock. Although ECLS cannot neutralize toxins or facilitate poison removal, it can restore end-organ perfusion until elimination of the toxin and/or end-organ recovery occur. Preferentially, ECLS is used as a "bridge to recovery," and as such, severe poisoning is perhaps one of the most ideal indications for its use. The aim of this article is to review the history of ECLS and provide an overview of basic physiologic principles, current techniques, indications, contraindications, complications, and its role in the treatment of the severely poisoned patient with refractory cardiovascular collapse.

Keywords:
extracorporeal life support; cardiogenic shock; cardiotoxicity; poisoning; toxicology; cardiopulmonary resuscitation

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Extracorporeal Life Support: Indications and Use in Severely Poisoned Patients

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A 14-year-old adolescent girl presented to the emergency department (ED) after an intentional ingestion of an unknown quantity of diphenhydramine. Initially, she was asymptomatic with unremarkable vital signs and physical examination results. Initial electrocardiogram showed sinus rhythm at 97 beats per minute with normal QTc and QRS duration. Several hours into her ED stay, she became somnolent and confused and had 20 minutes of generalized tonic-clonic seizure activity, terminated after administration of lorazepam and phenobarbital. The patient experienced recurrent and prolonged episodes of ventricular fibrillation and pulseless monomorphic ventricular tachycardia refractory to treatment with repeat defibrillation, epinephrine, sodium bicarbonate, calcium, lidocaine, and crystalloids. She was intubated, and cardiopulmonary resuscitation was initiated. She was given a 1.5 mL/kg bolus of Intralipid 20% followed by an Intralipid infusion of 0.25 mL/kg/min. Because of persistent cardiac arrest despite maximal conventional medical therapies, venoarterial extracorporeal life support (VA-ECLS) was initiated in the ED 8 hours after initial presentation. VA-ECLS was weaned 4 days post cardiac arrest, and she was extubated 3 days

later. The patient survived with residual mild ataxia and slight cognitive dysfunction.

INTRODUCTION

The primary cause of death in patients with severe poisonings is pulmonary and cardiovascular failure.[1] Early aggressive hemodynamic support with extracorporeal life support (ECLS) can be beneficial in patients with severe refractory toxin-induced shock. The aim of this article is to discuss the history of ECLS and provide an overview of basic physiologic principles, current techniques, indications, contraindications, complications, and its role in the treatment of the severely poisoned patient with refractory cardiovascular collapse.

CONTEXT

For more than 40 years, ECLS has been used to provide circulatory and/or pulmonary support in patients with severe respiratory failure or persistent cardiovascular collapse.[2] Over the past decade, technological advances in ECLS equipment have rendered its use outside the operating room more clinically viable.[3,4] Devices have become much more dependable, portable, and easier to manage. Enhanced biocompatibility and better understanding of anticoagulants have enhanced performance and improved patient safety.

The worldwide H1N1 influenza pandemic of 2009 triggered a renewed interest in the use of ECLS as a salvage therapy.[5] Venovenous ECLS (VV-ECLS) was used with relatively good success in many patients with H1N1 influenza and severe acute respiratory distress syndrome who did not respond to maximal ventilatory support. Mortality rates were low in these severely hypoxemic patients, around 25%.[5] As teams gained familiarity with the technology, ECLS was used for other indications, including severe poisonings.

CURRENT TECHNIQUES

ECLS consists of specialized cannulae that connect to a patient's circulation, a pump that drives blood through circuit tubing, and a membrane that oxygenates blood and removes carbon dioxide.[2,6,7] VV-ECLS maintains nonpulmonary gas exchange by accessing and returning blood from the venous system. Blood is first removed from the venous circulation through a large-bore central vessel, usually the femoral vein. Hypoxemic blood is then propelled forward by a centrifugal or roller pump, oxygenated via membrane oxygenator, and returned to the right atrium via the superior or inferior vena cava. In patients with severe acute lung injury, VV-ECLS ensures oxygen delivery to tissues, allowing time for lung recovery.[7] With VV-ECLS, the lungs are protected from high ventilation pressures, and the workload of the right ventricle may be reduced because of lower pulmonary vascular resistance.[7] Compared with VA-ECLS, pulmonary blood flow is preserved, which allows the lungs to filter small emboli that may occur. VV-ECLS does not provide any direct cardiac support. Therefore, it is not indicated for patients with cardiogenic shock.

In patients with severe cardiac failure or refractory cardiac arrest, VA-ECLS maintains gas exchange with the potential to provide complete cardiac support. With VA-ECLS, a large-bore cannula removes hypoxemic blood from the jugular or femoral vein, which is then pumped through an oxygenator and returned to the aorta through a large-bore arterial cannula. Central cannulation, in which cannulae are placed directly into the heart and great vessels after sternotomy, is also possible. VA-ECLS provides both pulmonary and circulatory support which is beneficial for patients with impaired cardiac function refractory to inotropes and vasopressors. It can be used during cardiac recovery in patients with insufficient cardiac output immediately after heart surgery or as a bridge to heart transplantation or placement of a permanent assist device. In a hemodynamically unstable patient with a massive pulmonary embolism, ECLS can be used as a bridge to pulmonary embolectomy. In children, ECLS has been used successfully in the setting of neonatal respiratory distress syndrome.[8] In the severely poisoned patient, ECLS can be used as a bridge to recovery, as toxin-induced cardiomyopathy is often temporary. Other potential indications include refractory cardiac arrest, severe traumatic injury, and severe respiratory failure.

INDICATIONS

Guidelines for initiation of VV-ECLS are derived mostly from patients with severe acute respiratory distress syndrome.[10] There is little published guidance on use of VA-ECLS. The Extracorporeal Life Support Organization recommends consideration of ECLS in the setting of acute severe heart or lung failure when the mortality risk is measured at 50% despite optimal conventional therapy and in most circumstances at 80% mortality risk.[11]

Determining if and when a severely poisoned patient may benefit from ECLS can be a difficult decision for clinicians. Periods of prolonged cardiovascular instability and lack of response to