Extracorporeal life support in cardiogenic shock: Impact of acute versus chronic etiology on outcome

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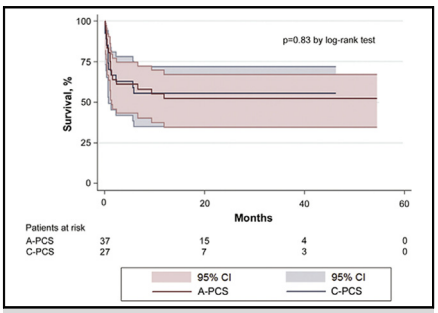
ABSTRACT

Background: The role of extracorporeal life support (ECLS) in primary cardiogenic shock (PCS) is well established. In this study, we evaluated the impact of etiology on outcomes.

Methods: Between January 2009 and March 2013, we implanted a total of 249 patients with ECLS; we focused on 64 patients for whom peripheral ECLS was the treatment for PCS. Of these, 37 cases (58%) were "acute" (mostly acute myocardial infarction: 39%); 27 (42%) had an exacerbation of "chronic" heart failure (dilated cardiomyopathy: 30%; post-ischemic cardiomyopathy: 9%; and congenital: 3%).

Results: In the group with chronic etiology, 23 patients were bridged to a left ventricular assist device (52%) or heart transplantation (33%). In the group with acute etiology, ECLS was used as a bridge-to-transplantation in 3 patients (8%), a bridge-to-bridge in 9 (24%), and a bridge-to-recovery in 18 (49%). One patient in each group was bridged to conventional surgery. Recovery of cardiac function was achieved in only the group with acute primary cardiogenic shock (18 vs 0 patients, $P = .0001$). A mean flow during support of $\leq$60% of the theoretic flow (body surface area $\times$ 2.4) was a predictor of successful weaning ($P = .02$). Median duration of ECLS support was 7 days (range: 2-11.5 days). Nine patients (14%) died during support; 30-day overall survival was 80% (51 of 64 patients); and 59% of patients were discharged, in whom survival at 48 months was 90%. Thirty-day survival was correlated with duration of ECLS support.

Conclusions: In "chronic" heart failure, ECLS represents a bridge to a ventricular assist device or heart transplantation, whereas in "acute" settings, it offers a considerable chance of recovery, and is often the only required therapy. (J Thorac Cardiovasc Surg 2015;150:333-40)



Overall survival of patients with primary cardiogenic shock with acute or chronic etiology.

Central Message

ECLS in C-PCS represents a bridge to VAD or heart-transplantation, whereas in A-PCS it offers chance of recovery. Better outcomes are observed with shorter and partial support.

Perspective

ECLS is a bridge-to-life and should be considered a first line treatment in PCS. Therapeutic strategy should be tailored considering the different outcomes with respect to etiology. Moreover, maintaining flows below 60% of the theoretical requirement and minimizing the duration of support appears to be the strategy which offers the best chance of survival.

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Acute cardiogenic shock is a condition that continues to have very high mortality despite advances in medical therapy.[1-3] Conventional treatment typically comprises inotrope infusions, vasopressors, and an intra-aortic balloon pump (IABP).[1,4] When circulatory instability is refractory to these treatments, mechanical circulatory support represents the only hope for survival, as indicated by current guidelines.[3,4]

As most of these patients present with critical circulatory instability that requires urgent or emergent therapy, the chosen mechanical assistance should be able to be rapidly and easily implanted. For this reason, extracorporeal life support (ECLS) is the ideal "bridge to life," and increasingly, it is used to keep patients alive while the optimal therapeutic management is determined ("bridge to decision"). Management may follow 1 of 3 courses: (1) a "bridge to recovery," which involves patient recovery and weaning from ECLS; (2) a "bridge to transplant," which involves direct orthotopic heart transplantation; and (3) a "bridge to bridge," which involves placement of a ventricular assist device or total, artificial, longer-term support.[5,6] Several large reports have been made on use of ECLS as a

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Abbreviations and Acronyms
AMI = acute myocardial infarction
A-PCS = acute primary cardiogenic shock
C-PCS = chronic primary cardiogenic shock
ECLS = extracorporeal life support
IABP = intra-aortic balloon pump

mechanical support in postcardiotomy patients[3,7-9]; but relatively few, most of which are small case-series studies, have focused on the role of ECLS in primary, cardiogenic shock (PCS) outside of the postcardiotomy setting.[10-13]

We present the results of our center's experience in the treatment of PCS with ECLS as a bridge to decision. Furthermore, we evaluated the impact of etiology on patient outcomes by comparing refractory PCS secondary to acute myocardial infarction (AMI), myocarditis, pulmonary embolism, and postpartum cardiomyopathy with acute decompensation of a chronic cardiomyopathy, including dilated cardiomyopathy, ischemic cardiomyopathy, and adult congenital heart diseases. In addition, we analyzed whether duration and magnitude of support predict weaning and survival.

METHODS

Patients

Between January 2009 and March 2013, a total of 249 patients were treated with ECLS in our center. We prospectively analyzed 64 patients implanted with the PLS (MAQUET, Cardiopulmonary AG, Hirrlingen, Germany) ECLS system for treatment of cardiogenic shock refractory to maximal inotropic and vasopressor therapy and treatment with IABP therapy, excluding postcardiotomy, pediatric, and respiratory supports. We divided patients into 2 groups, according to etiology. A total of 37 were assigned to the group with acute primary cardiogenic shock (A-PCS), for whom the primary cause was an acute event in a previously healthy heart, including 26 cases of AMI, 4 of myocarditis, 6 of pulmonary embolism, and 1 of postpartum cardiomyopathy. In the second group were 27 patients with chronic primary cardiogenic shock (C-PCS), in whom the etiology was an acute deterioration of a chronic cardiomyopathy, including 20 who had dilated cardiomyopathy, 5 who had ischemic cardiomyopathy (C-PCS), and 2 who had grownup congenital heart diseases (Table 1). Written informed consent was obtained from all patients, and the study was approved by our institutional review board.

Criteria for Extracorporeal Life Support Installation

Patients who met the criteria of profound cardiogenic shock due to pump failure were candidates for ECLS. Profound shock was defined as: systolic blood pressure of <75 mm Hg; a cardiac index of $\leq$1.8 L/minute/m^2, with left ventricular end-diastolic pressure of >20 mm Hg, despite multiple, high-dose, intravenous inotropic agents (dopamine $\geq$10 μg/kg/minute, dobutamine $\geq$10 μg/kg/minute, epinephrine $\geq$0.1 μg/kg/minute, and norepinephrine $\geq$0.1 μg/kg/minute) and/or IABP treatment, in association with clinical signs of pulmonary congestion; and impaired end-organ perfusion (renal, respiratory, and hepatic failure and altered mental status).[14] The diagnosis of impaired end-organ function required $\geq$1 of the following: altered mental status; cold, clammy skin and extremities; oliguria with urine output of <30 ml per hour; respiratory failure, defined as partial pressure of oxygen in arterial blood <60 mm Hg and/or partial pressure of carbon dioxide in arterial blood >45 mm Hg (type I-II), or need for mechanical ventilation in the setting of cardiogenic shock (type IV); serum lactate level >2.0 mmol per liter; bilirubin or transaminases >3 times the upper normal limit set by the local laboratory; and multiorgan failure, defined as failure of $\geq$2 organs, in addition to cardiac dysfunction.[4,15] The only absolute contraindication to ECLS was presence of severe neurologic involvement after arrest (significant anisocoria and signs of decerebration or focality); age >75 years and severe peripheral vascular disease were considered relative contraindications.[6]

Extracorporeal Life Support System

The system used in our institute was the PLS.[7,16] This system has a portable, "all-in-one" design, including an oxygenator (Quadrox D), a centrifugal pump (Rotaflow), and heparin-coated tubes, as well as an optional heat exchanger, with specific features to minimize thrombotic risk.[7,16] Furthermore, it has obtained CE (European conformity) approval for 14 days of support.

Extracorporeal Life Support Placement

In our institute, when feasible, we opted to implant ECLS with the patient awake and breathing independently, with local anesthetic, at the bedside. Cannulation was performed using a percutaneous veno-arterial Seldinger technique, with a venous drainage cannula (18F to 28F) placed in the femoral vein, and an arterial return cannula (18F to 22F) placed in the femoral artery. When this strategy was unsuccessful or contraindicated (eg, by significant peripheral vascular disease, with small femoral vessels), the patient was taken to the operating theater, sedated, and intubated.

At the surgeon's discretion, 1 of the following cannulation techniques was chosen: subclavian or inguinal dissection and anastomosis of a 6- to 10-mm Dacron vascular graft (FlowWeave, Jotec GmbH, Hechingen, Germany) onto the subclavian or femoral artery for cannulation. In a single case, a sternotomy and central cannulation (a venous cannula in the right atrium and an arterial cannula in the ascending aorta) were used. Limb ischemia subsequent to percutaneous femoral arterial cannulation was handled via distal cannulation using a smaller cannula (either percutaneous or surgical), or by shifting the cannulation site.

Anticoagulant Management

Before placement of cannulae, a heparin bolus of 70 U/Kg (usually 5000 units) was administered to obtain an activated clotting time of 180 seconds. After this step, we performed activated partial thromboplastin time, international normalized ratio, and antithrombin assays 4 times per day; platelet counts, fibrinogen, and d-dimer assays were conducted once daily. Patients were kept anticoagulated with heparin maintenance, and with activated partial thromboplastin time in the range of 50 to 60 seconds. When d-dimer was elevated, or in cases of hemorrhagic or thrombotic complications, a thromboelastometry was carried out, and targeted therapy, based on its results, was initiated.

Management of Extracorporeal Life Support

Extracorporeal life support is intended to be a bridge-to-life, and at first, all patients need full-flow support (patient's estimated required cardiac output, calculated as: body surface area $\times$ 2.4 l/minute). In this phase, stabilization is obtained, with cardiac function totally replaced by ECLS, which guarantees circulatory support and organ perfusion.

After this phase, some pulsatility may be observed, and this is a sign of initial recovery of cardiac function. In this second phase, we maintain inotropic support and the IABP when it is already present before ECLS implantation; we wake the patient to guarantee sympathetic tone; we perform weaning from mechanical ventilation, achieving extubation as soon as possible, to reduce pulmonary resistance; we start to reduce support, monitoring pulsatility and organ perfusion (lactate, urine output, central venous pressure, and pulmonary capillary wedge pressure). We maintain inotrope