Extracorporeal Membrane Oxygenation for Advanced Refractory Shock in Acute and Chronic Cardiomyopathy

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Background. **Extracorporeal membrane oxygenation (ECMO) has been used to obtain rapid resuscitation and stabilization in advanced refractory cardiogenic shock (CS), but clear strategies to optimize outcomes and minimize futile support have not been established.**

Methods. **We retrospectively reviewed our experience with ECMO in patients with advanced refractory CS, after an acute myocardial infarct (AMI) compared with patients receiving ECMO after an acute decompensating chronic cardiomyopathy (CCM).**

Results. **Between January 2003 and February 2009, 33 patients required ECMO support for advanced refractory CS secondary to AMI (AMI-CS) and 9 patients were supported by ECMO in the presence of an acutely decompensated CCM (CCM-CS). Survival at 30 days, 1 and 2 years for patients with AMI-CS, was 64%, 48%, and 48% compared with 56%, 11%, and 11% at the same time points for those with CCM-CS ($p = 0.05$). In the AMI-CS group, 14 of 33 (42%) patients were weaned directly from ECMO after revascularization; 15 of 33 (45%) patients were bridged to ventricular assist device (VAD) support and subsequently either underwent heart transplantation (n = 6), were successfully weaned from VAD (n = 2) or died while on VAD support (n = 7). In the CCM-CS group, 7 patients were bridged to VAD support (77%), with 1 patient surviving after VAD weaning.**

Conclusions. **Extracorporeal membrane oxygenation in advanced refractory AMI-CS is associated with acceptable outcomes in a well-selected population. The ECMO in patients with an acute decompensation of a chronic CM should be carefully considered, to avoid futile support.**

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Cardiogenic shock (CS) occurs in 7% to 9% of patients experiencing an acute myocardial infarction (AMI) with high mortality rates, despite all recent advances [1, 2]. A more aggressive strategy, including the use of mechanical support as a bridge to transplant or recovery, has been associated with improvement in survival compared with conservative treatment [3]. The delay in the referral of such patients with clinically advanced respiratory, hepatic, or renal failure for consideration of implantable or more permanent therapy is associated with poor outcomes [4, 5]. In these critical circumstances, extracorporeal membrane oxygenation (ECMO) has been utilized to obtain rapid resuscitation, stabilization, and subsequent triage to a more permanent treatment strategy. This concept, known as a "bridge-to-decision" or "bridge-to-bridge" (in the case of bridge to a more permanent device), may optimize patient survival and resource utilization [6–9].

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The advantages of ECMO include implantation simplicity, full circulatory and respiratory support, and lower cost compared with other systems available. Despite these evident benefits, disparate results have been reported regarding ECMO use in CS after AMI [6, 10, 11]. We reviewed our experience with the use of ECMO support for stabilization of patients in advanced refractory CS, secondary to an AMI, and compared them with patients who needed ECMO support for advanced refractory CS after acute decompensation of a chronic cardiomyopathy (CCM) in the absence of an acute coronary event (including idiopathic dilated and ischemic CCM).

Patients and Methods

Study Protocol

Between January 2003 and February 2009, 42 patients required the use of ECMO support at the UPMC (University of Pittsburgh Medical Center). In 33 patients, the primary cause of CS was a confirmed AMI, while in the other 9 patients the etiology was an acutely decompensated CCM (7 dilated and 2 ischemic) in the absence of an

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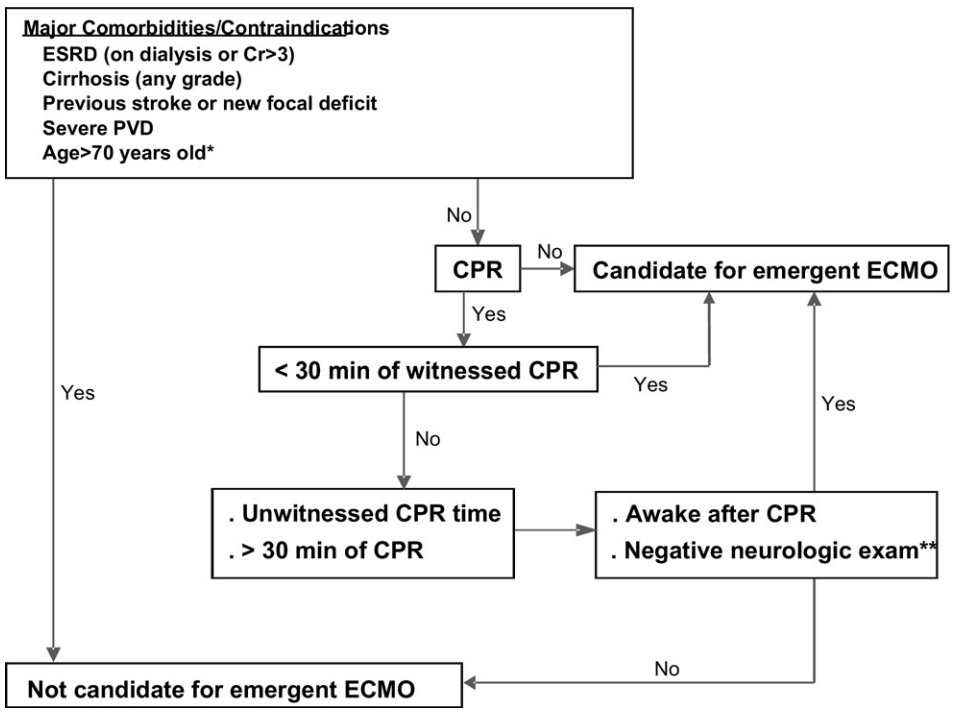

*Fig 1. Extracorporeal membrane oxygenator (ECMO) for cardiogenic shock inclusion criteria at UPMC. *Patients >70 years old presenting with acute myocardial infarction and large territories at risk, with adequate targets for revascularization would be considered in individual cases with the absence of neurologic involvement after arrest. **Absence of significant anisocoria and signs of decerebration or focality. (CPR = cardiopulmonary resuscitation; Cr = creatinine; ECMO = extracorporeal membrane oxygenator; ESRD = end-stage renal disease; PVD = peripheral vascular disease.)*

acute coronary event, as assessed by electrocardiographic, enzymatic, or angiographic criteria. Data were obtained from the UPMC transplant and mechanical support database and patients' charts. This study was reviewed and approved by the Institutional Review Board of the University of Pittsburgh. The informed consent requirement was waived.

Patient Selection

The ECMO implantation was considered in patients with advanced and refractory CS and severe hemodynamic instability despite high doses of inotropic support or an intraaortic balloon pump (IABP). Extracorporeal membrane oxygenator was chosen preferentially over direct ventricular assist device (VAD) implantation in patients with rapidly progressive hemodynamic instability, unclear neurologic status, advanced multiple organ involvement, or an unclear social situation (drug, alcohol addiction), making ECMO a "bridge to decision." Also included in this study were patients with refractory cardiac arrest or high risk of imminent death (ie, recurrent-refractory ventricular arrhythmias). Cardiogenic shock was defined by persistent systolic blood pressure less than 90 mm Hg, need for high doses of inotropic support (≥ 2 inotropes) to maintain systolic blood pressure greater than 90 mm Hg, or the use of IABP with signs of end-organ dysfunction defined by low urine output (<30 mL/hour) and peripheral signs of severe hypoperfusion. High dose inotropic support was considered as dopamine (≥10 μg/kg/minute), epinephrine (≥0.05 μg/kg/minute), dobutamine (≥10 μg/kg/minute), milrinone (≥0.5 μg/kg/minute), and norepinephrine bitartrate (Levophed) (≥0.05 μg/kg/minute).

Patient selection for ECMO support was based upon the hemodynamic parameters mentioned above and an ECMO inclusion protocol developed in our institution (Fig 1). Programmatically we considered all patients, initially, as potential transplant candidates, and therefore requested implementation of ECMO support, in the absence of major comorbidities and usual contraindications for transplantation [12-14]. Based on the high rate of morbidity and mortality reported in patients older than 70 years after ECMO support for CS, we also considered it as a relative contraindication for initiation of support, with the exception of those patients susceptible to revascularization and direct weaning from support [15, 16]. Patients requiring ECMO for postoperative CS, with failure to wean from cardiopulmonary bypass after failed revascularization surgery or other cardiac procedures, were excluded from this study.

ECMO Considerations

Percutaneous arteriovenous ECMO implantation (femoral artery and vein) was performed in 28 patients in the AMI-CS group and in all patients in the CCM-CS group. In most patients, arterial cannulation was performed using the Seldinger technique; only 2 patients required an open femoral technique using an 8-mm Dacron graft (DuPont, Wilmington, DE). Percutaneous femoral venous cannulation (25 to 29 French) was performed using the Seldinger technique in all cases. We favored implantation of the arterial and venous cannula in opposite sites to improve venous drainage in the side where the arterial cannula was located. Distal arterial limb perfusion was used selectively in 5 patients from the AMI-CS group and 1 patient from the CCM-CS group after noted absence of

distal Doppler signal or absence of pulse, using a 9-Fr cannula inserted distally or using a small separate distal incision; generally in the intensive care unit after ECMO implantation. Central cannulation was performed infrequently (5 patients) and was used in patients with poor or inadequate peripheral vascular access, the presence of significant clinical pulmonary edema, persistent absence of myocardial function, or to obtain adequate left ventricle (LV) drainage adding a left atrial or pulmonary artery vent.

Left ventricular decompression may be inadequate during peripheral ECMO support. We routinely perform transesophageal echocardiogram and maintain inotropic support (epinephrine 0.05 μg) to prevent LV dilatation. In cases of clinical pulmonary edema or echocardiographic signs of LV distension, we perform central cannulation or peripheral transseptal decompression. In 2 patients, we circumvented the use of central cannulation by implanting a second femoral venous cannula positioned transseptal in the left atrium.

Heparin was used for anticoagulation to maintain an activated clotting time of 180 to 250 seconds. Patients were progressively weaned from inotropes and alpha agents to avoid deleterious effects on end-organ perfusion. Complete discontinuation of inotropic support was avoided to maintain LV contractility and emptying in an attempt to prevent LV thrombus formation. If an IABP was placed prior to ECMO implantation it was generally continued after support initiation. In patients with signs of lower extremity malperfusion the IABP was removed to minimize the risk of vascular complications and direct femoral artery repair was performed to avoid prolonged heparin discontinuation.

In the AMI-CS group, the decision to wean a patient from ECMO or bridge to VAD was based on clinical stability, normalization, or improvement of individual organ function, underlying coronary anatomy, and myocardial function improvement after initial myocardial stunning. After signs of neurologic, respiratory, and hepatic recovery were noted (generally after 2 to 5 days of ECMO) efforts were made to obtain complete revascularization, including percutaneous intervention (PCI) and coronary artery bypass grafting (CABG). Percutaneous intervention was favored in patients with 1-vessel or 2-vessel disease with favorable anatomy to percutaneous angioplasty and stenting. Coronary artery bypass grafting was favored in patients with 3-vessel disease or unfavorable anatomy to PCI, considering the inability to use large doses of platelet-inhibiting agents and the increased risk of bleeding complications or early stent thrombosis in the setting of multiple stent placement and nonpulsatile continuous ECMO flow. Patients with acute decompensation of a CCM were generally not considered for elective ECMO weaning.

During the weaning trial, ECMO flows were progressively decreased to 1 L per minute and left and right ventricular function assessed with transesophageal echocardiogram. If adequate cardiac output ($>$ 2.2 L/minute) was maintained, without significant elevation of the filling pressures in the presence of an estimated ejection fraction 0.30 or greater, the patient was removed from ECMO support. Patients who failed the ECMO weaning trial or who had severe diffuse nonrevascularizable coronary disease were considered for VAD implantation as a bridge to transplantation.

Data Analysis

Continuous variables are shown as mean ± SD, median (range). Actuarial survival estimates were calculated using Kaplan-Meier life table analysis. The log-rank statistic was used to determine whether survival curves differed, with a p value less than 0.05 considered statistically significant. Statistical analysis was performed using SPSS version 18 (SPSS Inc, Chicago, IL).

Results

Demographic and clinical characteristics of the patients in both groups are presented in Table 1. Patients with CCM-CS had higher creatinine, bilirubin, and blood lactate levels at the time of initiation of ECMO support than patients with AMI-CS. Twenty-seven patients with AMI-CS (27 of 33; 82%) underwent an initial PCI attempt prior to or simultaneously with ECMO implantation. Revascularization was possible in 21 patients receiving ECMO for AMI-CS, by PCI alone (13 patients), CABG alone (3 patients), or PCI-CABG (5 patients). The PCI was performed previous to ECMO implantation in 11 patients and during ECMO support in 7 patients. All CABGs were performed concomitantly to ECMO weaning (8 patients). Length of ECMO support did not differ between the 2 patient groups (p = 0.91). The ECMO was terminally discontinued in 4 patients (4 of 33; 12%) with AMI-CS due to the absence of neurologic improvement (2 patients), large cerebellar stroke (1 patient), or progressive multiorgan failure (MOF) (1 patient), and in 2 patients with CCM-CS (2 of 9; 22%) due to progressive MOF.

In the AMI-CS group the sites of ECMO implantation were the following: 13 of 33 (39%) patients in the operating room, 8 of 33 (24%) patients in the catheterization lab, 7 of 33 (21%) in the intensive care unit, and 5 of 33 (15%) came on ECMO from an outside hospital. In the CCM-CS group, 8 of 9 (88%) patients were cannulated in the intensive care unit and 1 of 9 (12%) in the operating room.

Weaning directly from ECMO was possible in 14 of 33 (42%) patients with AMI-CS. Eight of these patients were weaned from ECMO after revascularization with CABG or PCI-CABG and 6 patients after revascularization with PCI alone. Average support time for the 14 patients with AMI-CS who were weaned from ECMO was 90 hours (26 to 352 hours). None of the patients with CCM-CS were weaned directly from ECMO.

When ECMO weaning was not possible, patients received VAD support. In our series, 15 of 33 (45%) patients with AMI-CS required VAD implantation after ECMO support (6 left (L)VAD, 7 biventricular VAD, and 2 right VAD) versus 7 of 9 (77%) patients with CCM-CS (2 left VAD, 5 biventricular VAD). No difference in the use of biventricular support was noted between the 2 groups (p = 0.37). After VAD implantation, 6 of 15 (40%) patients

Table 1. Demographic and Clinical Characteristics of the Patients in Both Groups

Patient Demographics	AMI-CS	CCM-CS	*p* Value
Total number	33	9	—
Mean age (range)	55 (32–80)	48 (28–69)	0.17
Sex (%)			
Male	27 (81)	8 (88)	1
Female	6 (19)	1 (12)	
Comorbidities (%)			
Renal failure	4 (12)	4 (44)	0.05
Diabetes	16 (48)	4 (44)	1
Dyslipidemia	14 (42)	4 (44)	1
Hypertension	23 (69)	4 (44)	0.24
Smoker	17 (51)	4 (44)	1
AMI			
Anterior	15 (45)	—	—
Inferior	11 (33)	—	—
Right ventricle involvement	6 (18)	—	—
Lateral	7 (22)	—	—
High doses of inotropic support	30 (90)	9 (100)	1
Cardiac arrest pre-ECMO (%)	17 (51)	8 (88)	0.06
IABP	31 (93)	6 (66)	0.05
Mechanical Ventilation	29 (87)	8 (88)	1
Mean lab values pre-ECMO (range)			
ALT/SGPT	328 (35–2209)	299 (11–1809)	0.89
AST/SGOT	531 (5–2201)	456 (21–1871)	0.76
Bilirubin	0.8 (0.2–1.5)	3.1 (0.7–5.6)	0.0001
CK	5197 (114–35210)	787 (66–2026)	0.02
CK-MB	203 (2–634)	12 (7–19)	0.0003
Creatinine	1.7 (0.9–5.3)	2.56 (1–5.7)	0.04
Lactate	5.8 (1.2–19)	11 (2.5–19)	0.005
Troponin–I	258 (32–1816)	0.86 (0.1–2.78)	0.0002
Mean pre ECMO LVEF (range)	20 (5–45)	14 (5–30)	0.12
Median time from AMI diagnosis to ECMO support (range)	24 hours (1–336)	—	—
Median time of ECMO support (range)	69 hours (3–352)	60 hours (1–274)	0.91

ALT = alanine aminotransferase; AMI = acute myocardial infarction; AST = aspartate aminotransferase; CCM = chronic cardiomyopathy; CK = creatine kinase; CK-MB = creatine kinase isoenzyme MB; CS = cardiogenic shock; ECMO = extracorporeal membrane oxygenation; IABP = intraaortic balloon pump; LVEF = left ventricle ejection fraction; SGOT = serum glutamic oxaloacetic transaminase; SGTP = serum glutamic pyruvic transaminase.

with AMI-CS underwent successful heart transplantation, 2 of 15 (13%) were weaned from VAD support, and 7 of 15 (47%) died while on VAD support. Median time of VAD support in the patients with AMI-CS was 106 days (range, 4 to 580 days). None of the 7 patients with CCM-CS who required VAD implantation underwent heart transplantation, with 6 of those dying while on VAD support and 1 patient successfully weaned from VAD support (LVAD) after stabilization and remarkable LV functional improvement after an acute decompensation of his CCM, secondary to an arrhythmic storm during a failed ablation.

Complications in patients while being supported on ECMO included severe vascular complications in 5 patients with AMI-CS (15%) and 1 vascular complication in a patient with CCM-CS (11%) ($p = 0.63$). In the AMI-CS group, 3 patients required distal lower extremity amputation early in our experience for reasons associated with cannulation or IABP use and 2 patients required fasciotomy for compartmental syndrome. One patient with CCM-CS had transient lower extremity ischemia requiring distal perfusion while on ECMO and femoral artery repair with complete recovery. Four patients (12%) with AMI-CS manifested neurologic complications (including 1 patient presenting cerebellar stroke) during ECMO. One of these patients recovered adequate neurologic function and 3 patients were withdrawn from support due to irreversible damage. One patient (11%) with CCM-CS developed a thalamic stroke, a neurologic complication associated with the use of ECMO, with full recovery from the event. Thirteen patients (39%) with AMI-CS and 4 patients (44%) with CCM-CS presented advanced renal failure requiring temporary dialysis ($p = 1.00$). Eight patients with AMI-CS (24%) and 3 patients

(33%) with CCM-CS presented a significant infection requiring prolonged antibiotic treatment while on ECMO ($p = 0.67$).

Survival After ECMO

Mean follow-up was 774 days (1 to 2,686 days) for the patients with AMI-CS and 136 days (1 to 752 days) for the CCM-CS patients. For all patients receiving ECMO for AMI-CS, 30-day, 1-year, and 2-year survival were 64%, 48%, and 48%, respectively; for all patients receiving ECMO for CCM-CS, survivals at similar time points were 56%, 11%, and 11% ($p = 0.05$) (Fig 2). For the 14 patients who received ECMO for AMI-CS, underwent revascularization, and were weaned from ECMO, survival was 79% at 30 days, 64% at 1 year, and 64% at 5 years, and did not differ significantly from the survival of the 15 patients with AMI-CS who underwent VAD implantation after ECMO support (67% at 30 days, 47% at 1 year, and 47% at 5 years; $p = 0.35$) (Fig 3). Of the 15 patients with VAD implantation after ECMO support for AMI-CS, 6 patients were successfully transplanted and, at 5 years, are all alive.

Early (<30 days) mortality occurred in 12 of 33 patients (36% mortality) with AMI-CS and 4 of 9 patients (44% mortality) with CCM-CS. Progression of MOF was the most frequent causes of early mortality (Table 2). In the AMI-CS group 1 patient developed MOF while on ECMO, 4 patients developed MOF after VAD implantation, and another developed MOF after ECMO weaning post PCI. All 4 cases of early mortality in patients receiving ECMO support for CCM-CS were due to progressive MOF; 2 while on ECMO and 2 after VAD insertion. Late mortality (>30 days) occurred in 6 patients with AMI-CS and 4 patients with CCM-CS (Table 3).

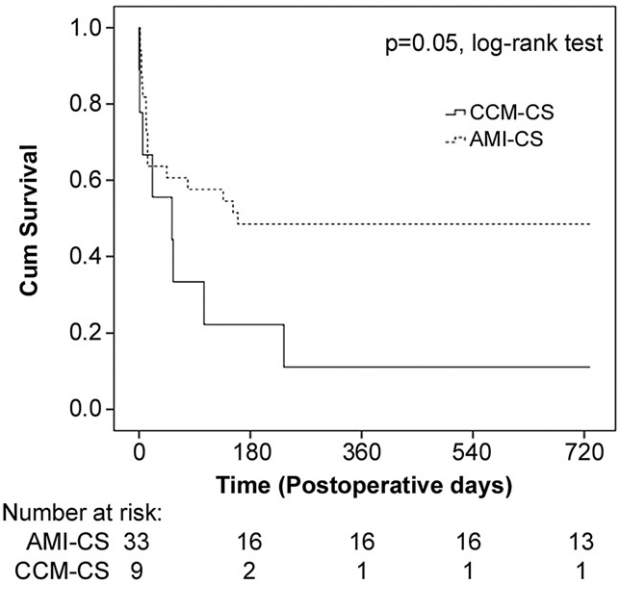

Fig 2. Kaplan-Meier survival curve of all patients supported on ECMO for CS (*considered all subsequent management strategy utilized, including revascularization, VAD, or heart transplantation). (— = CCM-CS; — = AMI-CS) AMI = acute myocardial infarction; CCM = chronic cardiomyopathy; CS = cardiogenic shock; Cum = cumulative; ECMO = extracorporeal membrane oxygenation.).*

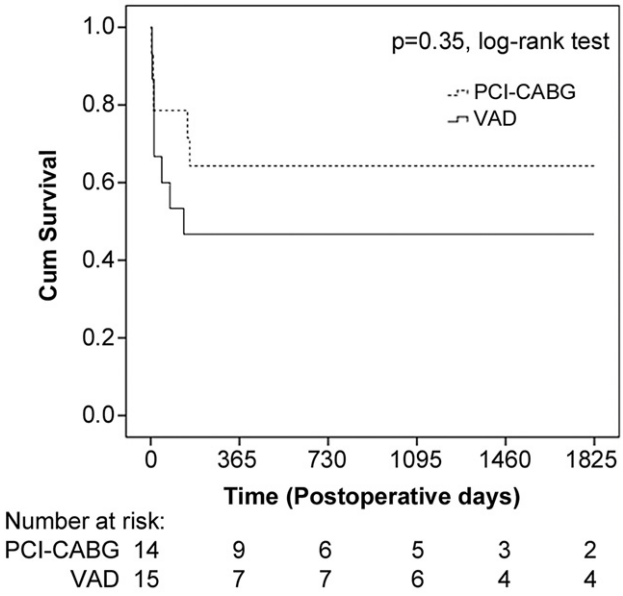

Fig 3. Kaplan-Meier survival of patients undergoing revascularization after ECMO weaning versus patients undergoing ECMO and subsequent VAD. (--- = PCI-CABG; — = VAD; CABG = coronary artery bypass grafting; ECMO = extracorporeal membrane oxygenation; PCI = percutaneous intervention; VAD = ventricular assist device.)

Comment

In this study, we report a single-center experience with the use of ECMO to stabilize patients with advanced refractory CS secondary to an AMI and unresponsive to medical management, including considerations for patient selection, implantation, and subsequent management. We found that ECMO provided effective support in patients after an AMI complicated by advanced refractory CS as a bridge to recovery or to a more durable support (VAD) while waiting for a heart transplant. Mechanical support in CS can restore hemodynamic stability and prevent or reverse organ dysfunction [4, 9]

Table 2. Causes of Early Mortality (<30 Days)

Etiology	AMI-CS (n = 12)	CCM-CS (n = 4)
CA (recurrent Vfib)	1	0
GI bleeding + ischemic CVA	1	0
Hypoxic encephalopathy	3	0
Cerebellar CVA	1	0
MOF	6	4

AMI = acute myocardial infarction; CA = cardiac arrest; CCM = chronic cardiomyopathy; CS = cardiogenic shock; CVA = cerebrovascular accident; GI = gastrointestinal; MOF = multiple organ failure; Vfib = ventricular fibrillation.

Table 3. Causes of Late Mortality (>30 Days)

Etiology	AMI-CS (n = 6)	CCM-CS (n = 4)
Hemorrhagic CVA on VAD	1	2
Heart failure	1	0
MOF	2	1
Sepsis	0	1
Unknown	2	0

AMI = acute myocardial infarction; CCM = chronic cardiomyopathy; CS = cardiogenic shock; CVA = cerebrovascular accident; MOF = multiple organ failure; VAD = ventricular assist device.

with the potential benefit of mechanically unloading the LV, decreasing its wall tension, oxygen consumption and, therefore, limiting the infarcted area, increasing the chances of myocardial recovery.

Historically, the direct use of a durable implantable VAD (eg, HeartMate XVE [Thoratec Corp, Pleasanton, CA], Novacor [Baxter Healthcare, Oakland, CA]) in patients requiring support for AMI-CS has been considered and reported. However, more recently physicians have reserved this strategy for more stable patients. The need for complex surgical procedures, the high "device" costs, and the need for trained personnel for surveillance have limited the use of durable implantable VADs to more stable patients [4, 5]. Recent reports with the use of percutaneous VADs have shown improvement in hemodynamic parameters but with no clear improvement in survival compared with the IABP, and recent controlled trials are suggesting a potential increase in bleeding and vascular complications [17, 18]. The use of a temporary, surgically implanted VAD (eg, Centrimag, Levitonix LLC, Waltham, MA; AB 5000, Abiomed Inc, Danvers, MA; percutaneous [p]VAD, Thoratec, Corporation, Pleasanton, CA) has been considered another alternative for support, providing adequate and reliable circulatory support in clinical [14].

Clinical series focusing the use of ECMO in AMI are limited. Early reports by Jaski and colleagues [10], Fujimoto and colleagues [6], and others [11] associated ECMO use with high mortality rates. More recent reports, including those by Chen and Liden, have shown higher rates of ECMO weaning and survival in this patient population, up to 63% in latter series [12, 13]. With the increasing number of institutions providing percutaneous temporary circulatory support, centers are facing the challenge of developing clear strategies to optimize outcomes, minimizing futile support. Variable patient selection, including prolonged reanimation, elderly population, patients with significant comorbidities, and absence of clear management strategy could have contributed to obscure the benefits of ECMO in some previous reports on the use of ECMO in AMI-CS [16].

Left ventricular unloading and hemodynamic stabilization allows the possibility of myocardial recovery after improvement of the initial stunning affecting the infarcted territory [12, 14]. The combination of revascularization (PCI or CABG) with ECMO support at the time of ECMO implantation or during support has the potential of enhancing myocardial recovery and increasing the possibility of direct weaning from support in these series [12]. Whether this improvement in function occurs early (days) after initiation of support or after weeks of support, as suggested by Anderson and colleagues [14], after more prolonged VAD support for AMI–CS, and whether this recovery could allow a safe weaning from ECMO, is still debated [16].

A clear delineation of contraindications to wean ECMO support safely is critical and, in our series, included severe advanced multivessel disease, the absence of improvement in LV function, preexistent organ dysfunction, and a history of CCM. In this series, 14 patients were weaned directly from ECMO support, demonstrating that this strategy is a valid alternative, as observed by other authors [12]. The decision to rely on early revascularization or bridge the patient to a more durable device as a bridge to transplantation should be made early (days) after patient stabilization. In our series, after patient stabilization and improvement in biochemical markers of organ dysfunction were observed, 42% of patients were weaned from ECMO with similar short-term to midterm survival presented by other recent reports [13].

In this series, the patients who received ECMO after an acute MI and then underwent heart transplant after a bridge with a VAD had excellent long-term survival. Others have also reported excellent outcomes using this aggressive strategy with heart transplant as the final treatment objective [3]. Although this aggressive strategy represents the ideal solution for this patient population, the scarcity of donors and the mortality while on the waiting list despite VAD support makes the attempt to wean patients directly from ECMO a worthwhile effort in selected cases, as observed in this series.

Our data suggest that patients presenting acutely after AMI can have acceptable outcomes after successful and timely implantation of support, especially in the absence of major comorbidities or neurologic involvement, and should be considered acceptable candidates for all treatment strategies presented here. However, our group of patients undergoing ECMO in the presence of CS secondary to an acute decompensation of a CCM offers a stark contrast. Differing from results of Hoefer and colleagues [8] using ECMO as a bridge strategy, in our study the patients with acute decompensation of chronic heart failure had poorer outcomes. The higher rates of systemic, hepatic, and renal involvement at presentation, manifested by higher creatinine, bilirubin, and lactate at the time of implant, demonstrates the lower reserve of these patients to an acute decompensating event.

Limitations of this study include the retrospective nature and biases inherent to this type of report. The limited number of patients included in each group may restrict the possibility of definite conclusions although representing a potential contribution due to the scarcity of reports in this specific topic. In addition this is an experience from a single institution with extensive VAD support and transplantation experience but the results may not translate to other centers with different patient populations, technologies available, and organ availability.

Our study demonstrates the effectiveness of ECMO support in patients after an AMI complicated by advanced refractory CS, as a bridge to recovery or to a more durable support (VAD) and subsequent heart transplantation, with acceptable midterm outcomes. Considering the advanced degree of cardiopulmonary support required and ease of implantation, the use of ECMO in AMI-CS in a well-selected population should be considered as a first line of support in patients presenting with severe refractory CS after an AMI and may be associated with better results than previously reported. We also suggest careful consideration of the use of this technology in patients with an acute decompensation of a CCM and advanced shock because the chronic nature of this disease may lead to poor outcomes in some of the cases.

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