Peripheral venoarterial extracorporeal membrane oxygenation improves survival in myocardial infarction with cardiogenic shock

Gilbert H. L. Tang, MD, MSc, Ramin Malekan, MD, Masashi Kai, MD, Steven L. Lansman, MD, PhD, and David Spielvogel, MD, Valhalla, NY

Despite early revascularization, cardiogenic shock complicating acute myocardial infarction carries high mortality. Intra-aortic balloon pump (IABP) support was recently found to confer no mortality benefit over medical therapy in the Intraaortic Balloon Pump in Cardiogenic Shock II (IABP-SHOCK II) trial.[1] This communication focuses on our experience with venoarterial (VA) peripheral extracorporeal membrane oxygenation (pECMO) in patients with acute myocardial infarction complicated by cardiogenic shock.

CLINICAL SUMMARY

From January 2010 to August 2012, 60 consecutive patients were referred to our institution with cardiogenic shock and all underwent VA ECMO placement. Of the 60 patients, 21 had acute myocardial infarction complicated by cardiogenic shock, defined as systolic blood pressure less than 80 mm Hg, despite inotropic and/or mechanical support. At presentation, all patients were supported by an IABP or Impella 2.5 device (Abiomed, Danvers, Mass). Their mean age was 61 years, 8 had been resuscitated from cardiac arrest, and the Acute Physiology and Chronic Health Evaluation IV scores indicated a 38% ± 15% (range, 7%-70%) predicted mortality (Table 1).

Two thirds of patients had an ECMO device implanted in the operating room. The ECMO circuit consisted of a centrifugal pump (Tandem Heart, Cardiac Assist Inc, Pittsburgh, Pa; Centrimag, Thoratec, Pleasanton, Calif; CardioHelp, Maquet, Wayne, NJ) and a Quadrox oxygenator (Maquet). A dual-stage femoral venous cannula (Estech, San Ramon, Calif) was used for venous inflow. We preferred to use the axillary artery for arterial outflow, using an 8-mm Hemashield graft (Maquet) secured to the ECMO circuit with a 1/4-to-3/8-in tubing connector and anastomosed end-to-side to the axillary artery.

TABLE 1. Patient characteristics (n = 21)

Characteristic	Value
Age (y)	61 ± 14
Women	7 (33%)
Hypertension	12 (57%)
Diabetes	9 (43%)
Hyperlipidemia	11 (52%)
Smoker	7 (33%)
Renal failure	1 (5%)
COPD	2 (10%)
PVD	4 (19%)
TIA/stroke	2 (10%)
History of MI	16 (76%)
History of CHF	8 (38%)
Cardiogenic shock	21 (100%)
Previous PCI	11 (52%)
Previous CABG	4 (19%)
Ventricular tachycardia/fibrillation	11 (52%)
Cardiac arrest requiring resuscitation	10 (48%)
IABP or Impella support before ECMO	21 (100%)
Predicted mortality from APACHE4 score	38% ± 16%
Catheterization laboratory	45% ± 16%
Operating room	36% ± 16%

Data presented as mean ± standard deviation or n (%). *COPD*, Chronic obstructive pulmonary disease; *PVD*, peripheral vascular disease; *TIA*, transient ischemic attack; *MI*, myocardial infarction; *CHF*, congestive heart failure; *PCI*, percutaneous coronary intervention; *IABP*, intra-aortic balloon pump; *ECMO*, extracorporeal membrane oxygenation; *APACHE4*, Acute Physiology and Chronic Health Evaluation IV; *CABG*, coronary artery bypass grafting.

Depending on the residual cardiac function and body surface area, we found that ECMO flows of 2.5 to 4.0 L/min generally achieved adequate tissue perfusion. The IABP or Impella device was left in situ to help offload the left ventricle and offset the increase in afterload produced by ECMO. Heparin was administered to a target activated clotting time of 200 to 240 seconds. The mean duration of support was 9.0 ± 7.5 days (range, 1-25 days). Echocardiography was used to assess left ventricular recovery and guide ECMO weaning and explantation. One patient developed acute leg ischemia, requiring conversion from femoral to axillary artery perfusion, but no other vascular complications developed.

Five patients died, for a 30-day mortality of 24% (Table 2). Of the 5 patients who died, 4 had had previous cardiac arrest, and in 2 of these cases, the cause was

From the Section of Cardiothoracic Surgery, Department of Surgery, New York Medical College, Westchester Medical Center, Valhalla, NY.

Disclosures: Authors have nothing to disclose with regard to commercial support.
Received for publication Sept 21, 2012; revisions received Nov 15, 2012; accepted for publication Dec 11, 2012; available ahead of print Jan 14, 2013.

Address for reprints: David Spielvogel, MD, Section of Cardiothoracic Surgery, Department of Surgery, Westchester Medical Center, 100 Woods Rd, Macy 114 W, Valhalla, NY 10595 (E-mail: SpielvogelD@wcmc.com).

J Thorac Cardiovasc Surg 2013;145:e32-3
0022-5223/$36.00

http://dx.doi.org/10.1016/j.jtcvs.2012.12.038

TABLE 2. ECMO implantation and outcomes data (n = 21)

Variable	Value
Implant data	
Location of ECMO implant:	
Catheterization laboratory	7 (33%)
Operating room	14 (67%)
Site of arterial outflow	
Percutaneous femoral (all placed in catheterization laboratory)	7 (33%)
Axillary (all placed in operating room)	14 (67%)
Duration of support (d)	9.0 ± 7.5
Outcomes	
30-day all-cause mortality	5 (24%)
30-day mortality by location of ECMO implant:	
Catheterization laboratory	4/7 (57%)
Operating room	1/14 (7%)
ECMO as bridge	
Recovery	9 (43%)
CABG	5 (24%)
LVAD/transplantation	2 (10%)
Prolonged ventilation	10 (48%)
Pneumonia	3 (14%)
Renal failure	1 (5%)
Stroke	1 (5%)
Irreversible neurologic injury	2 (10%)
Multiorgan failure	1 (5%)
Bleeding	2 (10%)
Vascular injury	0 (0%)
Septicemia	3 (14%)

Data presented as n (%) or mean ± standard deviation. *ECMO*, Extracorporeal membrane oxygenation; *CABG*, coronary artery bypass grafting; *LVAD*, left ventricular assist device.

irreversible neurologic or multiorgan injury. One patient died of persistent hypoxia and acidosis failing resuscitation, and one died of refractory shock and cardiac arrest despite ECMO and IABP therapy. Sixteen patients survived, all of whom were discharged: 11 patients were weaned off ECMO, 3 underwent coronary artery bypass grafting, and 2 underwent left ventricular assist device implantation and subsequent cardiac transplantation.

DISCUSSION

Myocardial infarction with cardiogenic shock still carries a staggering 40% mortality, with or without IABP support.[1] We hypothesized that peripheral, mechanical circulatory support with VA ECMO might yield better survival by augmenting systemic perfusion, allowing recovery or providing a bridge to an implantable left ventricular assist device or transplantation. An additional advantage of pECMO is that it can be rapidly deployed and, in contrast to a peripheral left ventricular assist device, such as the Tandem Heart (Cardiac Assist), does not require trans-septal puncture. Our experience has shown that in most patients, VA ECMO effected a rapid reversal of the metabolic sequelae of shock, with normalization of the arterial blood gases and lactate level and an improvement in renal and hepatic function within 12 to 24 hours. However, those with irreversible neurologic injury, multiorgan failure, or persistent metabolic acidosis, regardless of where the pECMO implantation took place (operating room or catheterization laboratory), had a poor prognosis.

One potential limitation in this approach was inadequate decompression of the left ventricle to allow for myocardial recovery. With a combination of pECMO, IABP, and low-dose inotropic support, we did not observe left ventricular distension and resultant pulmonary edema among our patients. However, a pulmonary artery vent or balloon atrial septostomy could be potential options to address this issue.[2] The observed 30-day mortality of 24% was a substantial improvement over the published results[1] and the Acute Physiology and Chronic Health Evaluation IV predicted mortality of 38% for this group. Along with other recent reports,[3,4] this experience suggests that pECMO might be a better management option for cardiogenic shock complicating acute myocardial infarction.

We would like to thank Lisa Vanderbeek and Cindy Yu for their assistance in this study.

References

1. Thiele H, Zeymer U, Neumann FJ, Ferenc M, Olbrich HG, Hausleiter J, et al. Intra-aortic balloon support for myocardial infarction with cardiogenic shock. *N Engl J Med*. 2012;367:1287-96.
2. Seib PM, Faulkner SC, Erickson CC, Van Devanter SH, Harrell JE, Fasules JW, et al. Blade and balloon atrial septosotomy for left heart decompression in patients with severe ventricular dysfunction on extracorporeal membrane oxygenation. *Catheter Cardiovasc Interv*. 1999;46:179-86.
3. Tsao NW, Shih CM, Yeh JS, Kao YT, Hsieh MH, Ou KL, et al. Extracorporeal membrane oxygenation-assisted primary percutaneous coronary intervention may improve survival of patients with acute myocardial infarction complicated by profound cardiogenic shock. *J Crit Care*. 2012;27:530.e1-11.
4. Kim H, Lim SH, Hong J, Hong YS, Lee CJ, Jung JH, et al. Efficacy of veno-arterial extracorporeal membrane oxygenation in acute myocardial infarction with cardiogenic shock. *Resuscitation*. 2012;83:971-5.