



Percutaneous Coronary Intervention under Extracorporeal Membrane Oxygenation Support for High-Risk Acute Myocardial Infarction with Cardiogenic Shock

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Acute myocardial infarction (AMI) complicated by cardiogenic shock is an uncommon, but fatal condition. It should be treated by early revascularization, including medication, percutaneous coronary intervention (PCI) or coronary artery bypass graft (CABG). Extracorporeal membrane oxygenation (ECMO) has been shown to lower the mortality rate associated with emergency PCI or CABG procedures in patients with unstable hemodynamics. We present a patient with coronary artery disease (CAD) consisting of triple vessel disease (TVD), a significant left main (LM) artery lesion, AMI and cardiogenic shock, who underwent PCI under ECMO support. There were no short-term or middle-term complications related to the PCI procedure; however, ECMO implantation led to a superficial wound infection. The patient was alive and well at six-month follow-up. We also review the literature regarding PCI under ECMO support for AMI complicated with cardiogenic shock patients.

Key words: ECMO, AMI, LM, cardiogenic shock, PCI, EuroSCORE.

INTRODUCTION

Coronary artery disease (CAD) is a dangerous disease with a prevalence rate of 8%-15% worldwide¹. The overall mortality rate of acute myocardial infarction (AMI) has decreased from 30%-40% to 5%-10% over the last three decades because of advances in revascularization. Those CAD patients who have significant left main (LM) lesions, left ventricle dysfunction (ejection fraction < 30%), AMI and cardiogenic shock are at high risk with a mortality rate of 45%-80%^{1,2}. Extracorporeal membrane oxygenation (ECMO) has been used to provide hemodynamic support since the 1980s. The use of ECMO during percutaneous coronary intervention (PCI) in a high-risk patient was first reported in 1989 by Taub et al.³. Revascularization by PCI is safe, easy and technically feasible in low-risk CAD patients, while coronary artery bypass graft (CABG) is the

procedure of choice in high-risk patients because it can achieve more complete revascularization and greater durability of patency. However, some high-risk patients refuse to undergo CABG or have multiple comorbidities that put them at prohibitively high surgical risk. In these situations, PCI under ECMO support provides an alternative treatment to CABG for revascularization⁴.

CASE REPORT

A 79 year old man underwent an endarterectomy to treat left carotid artery stenosis in September 2002. He had no history of other systemic disease, such as hypertension or diabetes. He was a heavy smoker (0.5 packs/day) for more than 50 years. In July 2006, he presented to a local hospital with a two-month history of progressively worsening palpitation and dyspnea on exertion. A non-ST-segment elevation myocardial infarction and acute renal failure were diagnosed. He was then referred to the emergency room of the Veteran General Hospital Taichung. EKG revealed ST depression in V4-6. He also had a creatinine level of 3.4 mg/dL and a troponin-I level of 23.4 ng/dL. He was immediately admitted to the cardiovascular intensive care unit where a Swan-Ganz catheter was inserted. His hemodynamic parameters were as follows: central venous pressure 12 mmHg, pulmonary artery wedge pressure 19 mmHg,

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blood pressure 90/40 mmHg, heart rate 100/min, respiratory rate 30/min, cardiac output 2.55 L/min and cardiac index (C.I.) 1.51 L/min/m². Chest X-ray showed severe pulmonary edema with arterial blood gas (pH 7.389, PaO₂ 48.6, PaCO₂ 28.2, HCO₃⁻ 16.7, base excess -6.7). The patient was intubated with an endotracheal tube and placed on mechanical ventilator support. Coronary angiography (CAG) performed the following morning revealed CAD-TVD with an LM lesion (LM ostium 85% stenosis, left anterior descending artery [LAD] proximal to middle 60%-80% stenosis, chronic total obstruction of left circumflex artery [LCx] and right coronary artery [RCA]) [Fig. 1 A, B]. An intra-aortic balloon pump (IABP) was inserted via the right femoral artery at the end of the procedure. Soon after the angiography procedure was completed, the patient developed low cardiac output (C.I. 1.89 L/min/m²) and went into cardiogenic shock. ECMO was immediately set up to stabilize the patient (VA mode, left femoral artery and vein) with a flow rate of 2.4-4.0 L/min. Emergency revascularization by PCI was indicated because the patient was at relatively low procedural risk of developing complications or of acute mortality compared with CABG (EuroSCORE 20, estimated mortality rate > 50%). His vital signs gradually returned to within normal limits under ECMO support.

Echocardiography revealed severe mitral regurgitation, moderate aortic regurgitation, generalized left ventricle hypokinesia and a left ventricle ejection fraction (LVEF) of 16%. After informing the family of the mortality rate and prognosis associated with the CABG and PCI procedures, the family chose to undergo PCI rather than emergency CABG surgery, regardless of the poor long-term prognosis. After three days of ECMO support, the patient's vital signs and urine output had become stable and he underwent successful PCI for the LM ostium lesion with a direct bare metal stent, for the proximal-middle LAD with a drug-eluting stent and for the LCx ostium with a plain balloon angioplasty and a cutting balloon angioplasty without any early complications. [Fig. 2 C, D, E] The patient was taken off ECMO support two days after successful revascularization by PCI and post-MI treatment. No immediate complications due to PCI or ECMO were noted. The IABP was removed and the patient was placed on inotrope support on the fourth postprocedural day, and the endotracheal tube was removed on the eighth postprocedural day. His cardiac output was checked at around 4.38-6.56 L/min without IABP and inotrope support. However, purulent discharge from the left femoral ECMO wound was noted on the tenth postprocedural day and the patient underwent surgical debridement. Renal function

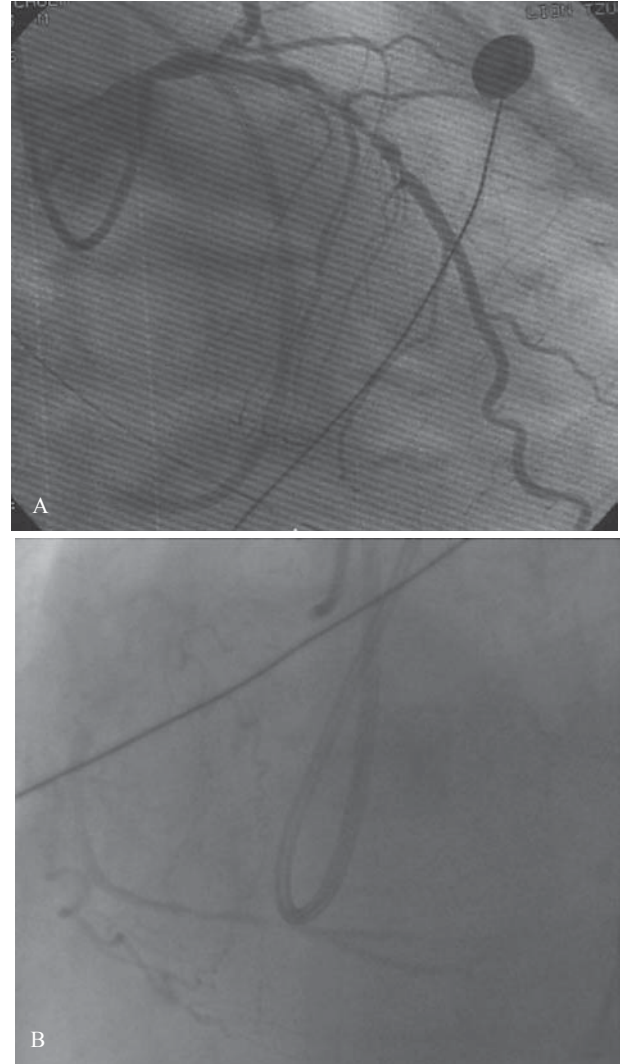


Fig. 1 (A) The coronary angiography showed 85% stenosis of left main (LM) lesion ostium, 60%-80% stenosis of the proximal left anterior descending artery (LAD), and chronic total occlusion of the left circumflex artery (LCx) ostium. (B) Chronic total occlusion of the middle right coronary artery (RCA) with bridging collateral from the LAD-septal branch to the posterior descending artery (PDA) and postero-lateral branch (PLB).

was gradually recovered and his blood creatinine level was Cr. 2.0 mg/dL on the sixteenth postprocedural day. The patient was discharged in stable condition 21 days after admission, and was followed up monthly in our cardiovascular OPD. He was alive and well with mild ambulant activity at six-month follow-up, while cardiography at the eight-month follow-up showed generalized left ventricular hypokinesia, severe mitral regurgitation, severe tricuspid regurgitation and an LVEF of 30%.

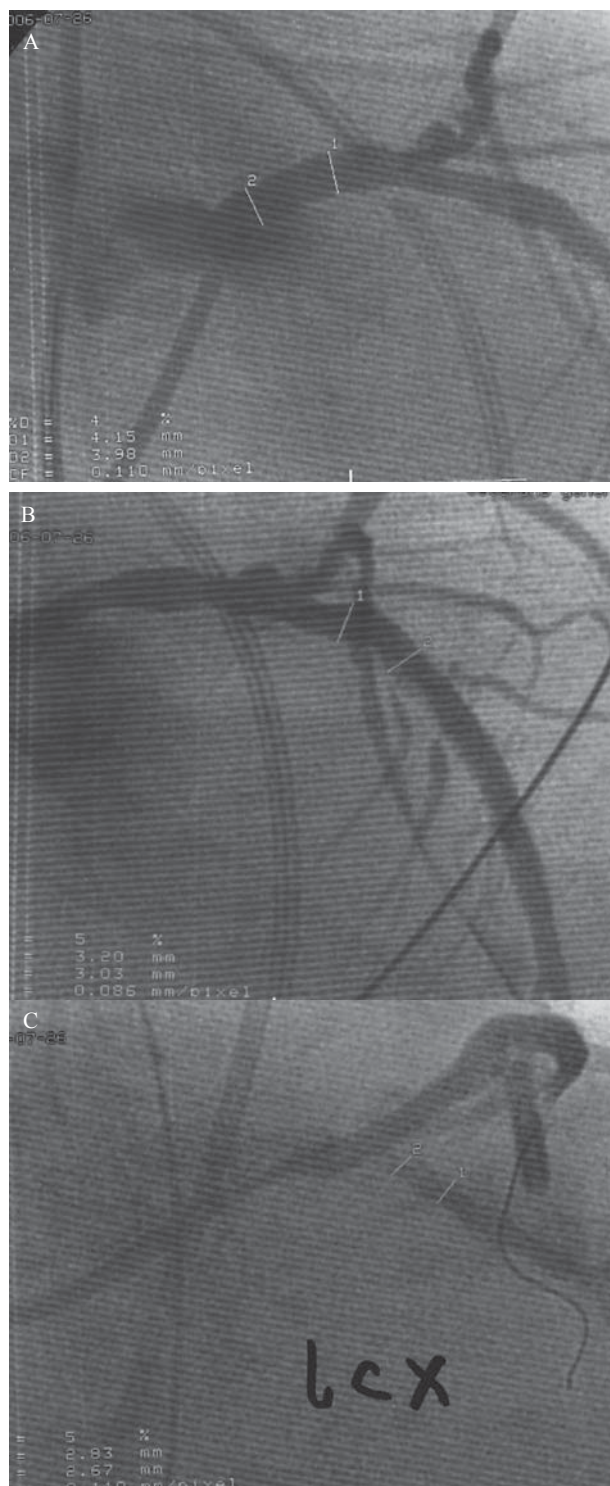


Fig. 2 The PCI was performed and revealed successful direct bare metal stenting for the LM ostium lesion (A), drug-eluting stenting for severe stenosis of the proximal-middle LAD (B), and plain balloon angioplasty and cutting balloon angioplasty for the LCx ostium (C).

DISCUSSION

In general, approximately 5%-10% of patients with AMI go into cardiogenic shock. The mortality rate in these patients is exceedingly high and reaches 70%-80% in those treated conservatively⁵. Patients who undergo early revascularization with either PTCA or CABG have lower in-hospital mortality than those who are treated conservatively. Nonrandomized, retrospective studies have reported a pooled 45% in-hospital mortality rate in AMI patients who undergo PCI during hospitalization for AMI complicated with cardiogenic shock and a 35% in-hospital mortality rate in AMI patients who undergo CABG surgery during hospitalization^{1,2,5}. However, some selection bias caused by highly skilled clinicians may account for such low mortality rates.

Emergency PTCA and CABG are proven modalities for treatment of cardiogenic shock complicated by acute MI. Whether they reduce mortality and which subgroups could potentially most benefit remains to be determined in the SHOCK trial that is ongoing⁵. AMI patients who go into cardiogenic shock are usually treated initially with an IABP for heart support. However, it has been reported that ECMO provides much more effective hemodynamic support than an IABP and that it should be performed early to stabilize the patient⁶. In our hospital, ECMO setup can be achieved within one hour, especially in the postoperative room. Our team of physicians, ICU nurses and a perfusionist is dedicated to the care of patients once the ECMO is set up. Thereafter, early revascularization, either by the PCI or CABG, can be considered.

PCI procedures are advantageous because they are easy to perform, do not require general anesthesia, thoracotomy or cardiopulmonary bypass, are not associated with CNS complications and result in a relatively short convalescence period. However, PCI procedures carry a high rate of early restenosis and are ineffective for treating most totally occluded and diffusely atherosclerotic coronary arteries. Patients with stable CAD or localized lesions are good candidates for PCI. Uwe Zeymer et al. reported that the total in-hospital mortality of AMI complicated with cardiogenic shock in patients undergoing primary PCI was 46.1%. Furthermore, the highest mortality was observed in patients with occlusion of the LM stem as the infarct-related artery¹. The ECMO support can provide effective hemodynamic stability and aggressively rescue AMI patients who go into cardiogenic shock. This allows the cardiologist to perform PCI to treat significant LM lesions or totally occluded CAD with less risk to the patient^{6,7}.

The advantages of CABG are greater durability (graft

patency rate > 90% at 10 years with artery conduit) and more complete revascularization irrespective of the morphology of the obstructing atherosclerotic lesion⁷. The benefits of CABG in patients with AMI complicated by cardiogenic shock may include protection of ischemic myocardium with cardioplegia and ventricular decompression with cardiopulmonary bypass. In Harvey's study, including the results of the SHOCK trial, the survival rates at 30 days were 55.6% in the PCI group compared with 57.4% in the CABG group ($P = 0.86$), and at one year 51.9% compared with 46.8%, respectively ($P = 0.71$). However, those selected for CABG were more likely to have diabetes and to have more severe coronary disease than those selected for PCI. In cases in which PCI is unlikely to achieve complete revascularization or there are associated mechanical complications or LM or severe triple-vessel coronary disease, CABG should be performed. Emergency CABG is an important component of an early invasive strategy in patients with cardiogenic shock².

Our patient was a high-risk CAD patient. He was 79 years old, had left carotid stenosis treated with endarterectomy, AMI, went into cardiogenic shock during CAG procedures and received ECMO support, had unstable angina under heparin and isosorbide dinitrate injection, a reduced LVEF of 16% and impaired renal function (Cr. 3.6 mg/dL). CABG was advised because it provides more complete revascularization and has a good long-term prognosis. However, the patient's family favored the less invasive PCI for revascularization because it has a lower acute mortality rate. Therefore, he was treated by PCI under ECMO support.

Complications following PCI procedures include death, AMI, the need for emergency CABG, stroke, complications at the vascular access site and contrast-induced nephropathy. There were no complications associated with the PCI procedure in our patient. Complications associated with the ECMO access site occur in up to 13% of patients and include femoral artery occlusion, distal limb ischemia, deep vein thrombosis, hematoma, retroperitoneal bleeding, infection, femoral nerve palsy, arteriovenous fistula and arterial laceration⁸. A superficial access site infection was the only complication of ECMO in our patient, and the wound healed well after debridement and suture.

The mortality for CAD patients with significantly reduced LVEF (< 20%) who undergo PCI under ECMO support is much lower than that in CAD patients who undergo CABG with cardiopulmonary bypass (4.8% versus 18.8%, respectively)⁸. However, in multicenter prospective studies, Wong et al. and Silvestri et al. reported that application of ECMO was not warranted in low-risk

patients with normal LVEF, given its higher complication rate and lack of proven benefit. These studies also revealed that the success rate of PCI procedures under ECMO support for high-risk patients was near 100%, the acute mortality rate was 0%, the one-year mortality was 2.0%-2.5% and the restenosis rate was 20%-23%, which means a poor long-term prognosis. It is believed that in patients with AMI complicated by cardiogenic shock, a very low acute mortality rate can be achieved by PCI under ECMO support^{9,10}.

In general, PCI or CABG are considered a definite option for treatment of stable CAD patients, but the relative merits and survival benefits for these procedures may differ in patients with cardiogenic shock. In the SHOCK trial, revascularization was associated with lower in-hospital mortality in patients who went into cardiogenic shock, and the mortality rate was 40%-50% in both PCI and CABG subgroups². However, Babaev's study showed that CABG is underused in patients with cardiogenic shock, with only 4.9% having early CABG in 2001¹¹. This underuse may indicate the difficulties in arranging emergency CABG for patients with cardiogenic shock, especially at night or during the weekend. The invasiveness of CABG and the many advances in PCI may also be reasons. Furthermore, PCI under ECMO support for cardiogenic shock patients has been proven a safer and less invasive treatment for revascularization, with an 80%-100% success rate in several studies^{9,10}. Thus, PCI under ECMO support provides a technically feasible and safe treatment for cardiogenic shock patients who refuse CABG or have a prohibitively high surgical risk due to multiple comorbidities.

CONCLUSION

ECMO provides an effective hemodynamic support for AMI patients who go into cardiogenic shock. PCI with ECMO support is a safer and less invasive treatment that has a lower procedural risk and acute mortality than CABG for high-surgical-risk patients.

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