Translated by E.V. Trushina

Case report

https://doi.org/10.23934/2223-9022-2024-13-1-128-133

Our Experience in Using Extracorporeal Membrane Oxygenation in Patients with Refractory Cardiogenic Shock

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BACKGROUND Veno-arterial extracorporeal membrane oxygenation (VA ECMO) is a critical care treatment option for patients with refractory cardiogenic shock. This method of temporary support of the cardiorespiratory system gives us and the patient time to restore organ function or is a «bridge» to other methods of treatment. Nevertheless, the issue of identifying the optimal time for VA ECMO implantation in patients with acute myocardial infarction complicated by refractory cardiogenic shock remains relevant.

AIM To evaluate the efficiency of extracorporeal membrane oxygenation in various clinical situations in patients with acute myocardial infarction complicated by refractory cardiogenic shock and post-infarction damage to the valves of the heart.

MATERIAL AND METHODS We present 3 patients with acute coronary syndrome complicated by refractory cardiogenic shock, of different age groups and comorbidities, who underwent veno-arterial extracorporeal oxygenation in various SCAI shock stages, and mechanical complications associated with acute myocardial infarction.

RESULTS In all the cases, stabilization of hemodynamics and heart function was achieved, and there were no hypoxic disorders of organs. In one case, a hemorrhagic complication associated with the VA ECMO procedure was noted. In one case, VA ECMO was performed as an intermediate stage for the correction of post-infarction mitral valve injury.

CONCLUSION These clinical cases demonstrate the efficiency of the timely start of VA ECMO before the development of organ dysfunction, which allows restoring myocardial function, and helps maintain hemodynamic normalization before the cardiac surgical stage of treatment.

Keywords: acute myocardial infarction, cardiogenic shock, high-risk percutaneous coronary intervention, SCAI scale (Society for Cardiovascular Angiography and Interventions), extracorporeal membrane oxygenation

For citation Markov YuN, Khafizov RR, Dumanyan ES, Zagidullin BI, Mukhamadeev MF. Our Experience in Using Extracorporeal Membrane Oxygenation in Patients with Refractory Cardiogenic Shock. *Russian Sklifosovsky Journal of Emergency Medical Care*. 2024;13(1):128-133. https://doi.org/10.23934/2223-9022-2024-13-1-128-133 (in Russ.)

Conflict of interest Authors declare lack of the conflicts of interests

Acknowledgments, sponsorship The study has no sponsorship

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AMI – acute myocardial infarction
BP – blood pressure
CHD – coronary heart disease
CPR – cardiopulmonary resuscitation
CS – cardiogenic shock
LA – left atrium
LCA – left coronary artery
LV – left ventricle
PCI – percutaneous coronary intervention
SCAI – Society for Cardiovascular Angiography and Interventions
VA ECMO – veno-arterial extracorporeal membrane oxygenation

INTRODUCTION

Extracorporeal membrane oxygenation (ECMO) is an advanced life support treatment for critically ill patients with refractory respiratory or cardiac failure. The first reports of long-term extracorporeal oxygenation in a patient with severe respiratory failure date back to 1971 and represent the beginning of ECMO as we know it today [1, 2].

Cardiogenic shock (CS) is a fatal condition that requires intensive care with an optimal algorithm to restore vital functions [3]. In particular, patients with CS refractory to inotropic therapy have an extremely poor prognosis, and several mechanical circulatory support devices, including veno-arterial (VA) ECMO, were developed to support these patients until recovery [4–6]. Currently, there is no generally accepted scale for determining the severity of CS; in our practice, we use the Society for Cardiovascular Angiography and Interventions (SCAI) scale, which, in our opinion, is optimal for determining the indication for mechanical cardiac support [7].

The use of ECMO is steadily increasing [8]. However, the mortality rate of patients with refractory CS undergoing VA ECMO remains quite high [9, 10]. In this category of patients, the question of determining the optimal duration of ECMO in order to achieve its maximum positive effect remains relevant. Although several studies assessed the impact of early ECMO support, most were limited to patients with CS complicating acute myocardial infarction (AMI), and determined the optimal timing of ECMO only in relation to percutaneous coronary intervention (PCI) [11–13]. In this regard, we provide our successful experience of using VA ECMO in various clinical situations in patients with CS secondary to AMI.

Aim: to evaluate the effectiveness of ECMO in various clinical situations in patients with AMI complicated by refractory CS and post-infarction damage to the heart valve apparatus.

MATERIAL AND METHODS

Our clinical case series is represented by 3 patients with AMI complicated by refractory CS. In one case, the patient experienced avulsion of the posterior papillary muscle of the mitral valve due to acute transmural myocardial infarction of the anterolateral wall of the left ventricle (LV).

In all the cases, patients had characteristic complaints upon admission: pain in the chest radiating to the left arm and shoulder blade, weakness, shortness of breath, cold sticky sweat.

Upon admission, all the patients underwent clinical and diagnostic procedures in accordance with the standards of care for AMI: medical history, electrocardiography, quantitative cardiac-specific troponin I, lactate analysis, coronary angiography, echocardiography and blood pressure (BP) monitoring.

In two cases, patients had a history of coronary heart disease (CHD), uncorrected hypertension, and in one case, insulin-dependent (type 1) diabetes mellitus, and pre-hospital thrombolytic therapy without effect (Table 1).

According to coronary angiography, in one case the patient was diagnosed with acute left main coronary artery (LCA) occlusion (Fig. 1). In two cases, occlusive-stenotic lesions of the left artery were detected. All the patients were classified as “high-risk PCI” due to multi-vessel disease, anatomical features of the coronary bed, and severity of the condition.

Table 1
Clinical and demographic data

Patient	1	2	3
Gender	M	F	F
Age, years	39	66	63
History of coronary heart disease	No	Yes	Yes
Hypertonic disease	No	Yes	Yes
Diabetes	Yes	No	No
Prehospital thrombolytic therapy	Yes	No	No
Blood troponin I level, pg/ml	125	573	2660
Blood pressure, mm Hg	80/60	115/98	130/90
Intraoperative echocardiography (ejection fraction, %)	35	48	40; mitral valve chord avulsion
Blood lactate level, mmol/l	5.3	1.5	2.9

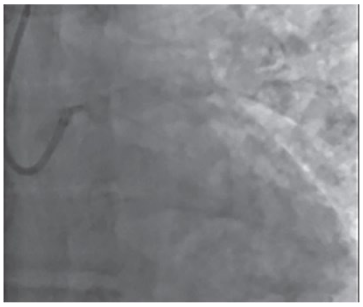

Fig. 1. Coronary angiography. Direct projection. Acute left main coronary artery occlusion

Fig. 2. Radiography. Direct projection. Position of venous and arterial cannulas

RESULTS

All the patients underwent VA ECMO at various time intervals, depending on the severity of the condition and clinical diagnostic data.

In the first case, a decision was made to preventively install ECMO due to refractory CS (stage B on the SCAI scale) and left main coronary artery occlusion. According to the standard protocol, puncture and cannulation of the right femoral vein and artery were performed under fluoroscopic control (Fig. 2).

The right superficial femoral artery was also catheterized with a 6 Fr catheter to ensure blood flow through the right lower extremity and prevent ischemia (Fig. 3).

Fig. 3. Right lower extremity angiography. Direct projection. The position of the retrograde arterial cannula for lower limb perfusion, the blood flow in the arteries is satisfactory

The patient underwent complete revascularization of the LCA.

In the second case, circulatory arrest occurred during revascularization. Cardiopulmonary resuscitation (CPR) was started: transfer of the patient to mechanical ventilation, chest compressions. Inotropic support without effect (norepinephrine 0.8 mcg/kg/min), followed by the development of refractory CS, stage C on the SCAI scale. During CPR, VA ECMO was implanted. Start of ECMO was 6 minutes after the start of CPR. Hemodynamics was stabilized: blood pressure was 100/55 mm Hg, heart rate (HR) was 115 beats/min. Full revascularization of the LCA was performed. In the postoperative period, a pulsating hematoma of

the cannulation site with the development of hemorrhagic shock was revealed. The post-puncture hematoma was inspected, and linear damage to the lateral wall of the common femoral artery in the area of the arterial cannula entry point was revealed. Suturing and complete hemostasis, drug and blood transfusion therapy were performed, followed by relief of hemorrhagic shock.

In the third case, after successful revascularization of the LCA, taking into account mechanical damage to the valvular apparatus of the heart in the form of avulsion of the posterior papillary muscle of the mitral valve, untreated CS during drug treatment (norepinephrine 0.4 mcg/kg/min, dobutamine 5 mcg/kg/min, furosemide 0.1–0.2 mg/kg/hour), and mechanical ventilation with FiO2 95%, Psupp 28 cmH2O, PEEP 8 cmH2O, SCAI stage D, right heart catheterization with a Swan Ganz probe: cardiac index 2.3 l/min/m2, pulmonary capillary wedge pressure of 30 mm Hg, a decision was made to install VA ECMO for hemodynamic stabilization as an intermediate step before surgical repair of the mitral valve. A cannula was inserted into the left atrium (LA) to reduce the preload on the LV in the X-ray operating room. A puncture of the interatrial septum was performed, and a 25 Fr, 60 cm cannula was inserted into the LA (Fig. 4).

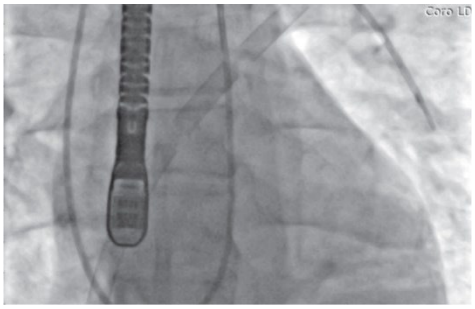

Fig. 4. Position of the venous cannula in the left atrium

In all presented cases, we noticed restoration of cardiac function, and the absence of multiple organ failure and other complications associated with CS severity and the ECMO procedure itself, based on the results of instrumental and laboratory tests – ejection fraction (EF), LV outflow tract velocity time integral (LVOT VTI), lactate and diuresis rate – with one exception of the development of hemorrhagic shock after arterial cannulation.

The average time from patient admission to the hospital to the start of ECMO (door-ECMO) was 75 minutes. The average duration of ECMO was 149 hours. The average hospital stay was 22 days (Table 2).

Table 2

Procedural indicators of ECMO

Patient	1	2	3
Door–ECMO, min	48	95	83
Duration of ECMO, h	90	127	230
Weaning options			
Ejection fraction, %	40	47	55
Velocity time integral, cm	15	17	18.5
Blood lactate level, mmol/l	1.3	1.5	1
Diuresis rate, ml/kg/hour	1.2	1.1	1.4
Inotropic support	no	no	no
Complications			
Multiple organ failure	no	no	no
Neurological	no	no	no
Hemorrhagic	no	yes	no
Infectious	no	no	no
Discharge from hospital, days	18	20	28

Note: ECMO — extracorporeal membrane oxygenation

DISCUSSION

Veno-arterial (VA) ECMO is a versatile tool that provides significant hemodynamic support in diverse patient populations. Its use helps achieve hemodynamic stabilization in patients outside the operating room, as well as improve outcomes in patients with cardiac arrest or refractory CS. The use of ECMO has expanded significantly over the past decade [14].

We presented a series of clinical cases that included 3 patients with various stages of refractory shock according to the SCAI scale and the mechanical complication: mitral valve chord avulsion associated with AMI. All of them received mechanical cardiac support via VA ECMO connection at various stages of PCI, as well as a life-saving intermediate step before surgical repair of the mitral valve.

In the first case, the preventive use of circulatory support ensured optimal performance of endovascular surgeons during high-risk PCI, early stabilization of the patient, and the absence of complications associated with the ECMO procedure.

In the second case, we had a hemorrhagic complication after implantation of VA ECMO during CPR. In our opinion, it is preferable to implant VA ECMO before the PCI procedure, as in the first case, since the patient was initially classified as high-risk PCI due to multivessel occlusive-stenotic lesions, age and severity of the condition.

Using the example of the patient with the mechanical complication of myocardial infarction, we showed that the use of early circulatory support, coupled with other methods, makes it possible to prepare the patient for surgical intervention aimed at treatment for AMI complications. In this case, we did not have any complications associated with the ECMO procedure either.

In all the cases, we noticed a decrease in hypoxic organ damage, which was manifested in the absence of the need for mechanical ventilation, renal replacement therapy or their short-term use.

A study conducted by H.H. Lee et al. in patients with refractory CS undergoing VA ECMO demonstrated that early ECMO support was associated with a lower risk of 30-day mortality compared with late ECMO support. Earlier ECMO implantation was also associated with a reduced risk of in-hospital mortality, failure of ECMO weaning, a combination of all-cause mortality or 1-year readmissions for heart failure, 1-year all-cause mortality, and adverse neurological outcome at discharge. However, the incidence of adverse events, including stroke, limb ischemia, ECMO site bleeding, and gastrointestinal bleeding, did not differ significantly between the groups [15].

Also, a number of studies by other authors demonstrated similar results, which generally support the concept of "the sooner the better". Recent observational studies from Taiwan [16, 17] and Korea [18] confirmed that early PCI with ECMO reduces the risk of adverse clinical outcomes in patients with AMI complicated by refractory CS. In addition, the interval between ICU admission and ECMO initiation was significantly shorter in survivors than in non-survivors in the extracorporeal life support cohort, although the difference was attenuated after multivariate adjustment [19].

Despite the high mortality rate in refractory CS, ECMO support can prolong the therapeutic window, allowing the heart to restore contractile function, and compensate for organ disorders resulting from hypoperfusion [20].

CONCLUSION

The presented series of clinical cases showed the effectiveness of veno-arterial extracorporeal membrane oxygenation when used in a timely manner in patients with refractory cardiogenic shock, both as an independent tool leading to recovery and as a "bridge" to the next stages of treatment.

Thus, the timely start of extracorporeal membrane oxygenation in the presented series of clinical cases made it possible to prevent the development of organ dysfunction, restore myocardial function, and also contributed to maintaining the normalization of hemodynamics before the surgical stage of treatment.

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Received on 12/01/2023
Review completed on 20/10/2023
Accepted on 20/10/2023