

The role of extracorporeal membrane oxygenation in obstetric emergencies with unexpected refractory shock

Y. Hye Ju¹, C. Woo Hyun¹, L. Dong-Hyung², K. Hwi Gon², S. Yong Jung², B. Ki Sup¹, K. Hyeon Seok¹,
Y. Seong Hoon¹, L. Seung Eun¹, K. Do Hyung³, J. Doosoo¹, K. Yun Seong¹

¹Department of Pulmonology and Critical Care Medicine, ²Department of Obstetrics and Gynecology, ³Department of Thoracic and Cardiovascular Surgery, Pusan National University Yangsan Hospital, Yangsan (Republic of Korea)

Summary

Extracorporeal membrane oxygenation (ECMO) has been used with increasing frequency to support obstetric patients with severe cardiac or pulmonary failure. Particularly, ECMO is required for successful cardiopulmonary resuscitation in cases of obstetric emergencies with unexpected refractory shock, which is most likely the only option to save the life of those patients. Here the authors present four cases who were treated with ECMO for cardiorespiratory support in obstetric emergencies with unexpected refractory shock. In conclusion, ECMO could be a valuable means of bridging therapy to save the life of a patient with obstetric emergencies who develops cardiopulmonary collapse.

Key words: Extracorporeal membrane oxygenation; Shock; Obstetric emergency.

Introduction

Extracorporeal membrane oxygenation (ECMO) has been used with increasing frequency to support obstetric patients with severe cardiac or pulmonary failure, which is most likely the only option to save the life of those patients [1-3]. Here the authors present four cases who treated ECMO in obstetric emergencies with unexpected refractory shock.

Case Report

Case 1

A 36-year-old woman gravid 2 para 1 at 21 weeks of gestation was admitted to the emergency room with fever and abdominal pain. She was pregnant with twin via in vitro fertilization. Her initial vital signs were blood pressure 73/32 mmHg, heart rate 148 beats/minute, respiratory rate 35 breaths/minute, body temperature 41°C, and pulse oximetry 79% in room air. Physical examination showed uterine tenderness. The blood tests revealed an elevation of inflammatory markers (white blood cell count $34 \times 10^9/L$, C-reactive protein 24 mg/L). Despite volume resuscitation and vasopressors treatment, septic shock and cardiopulmonary failure were deteriorating, which was induced by acute respiratory distress syndrome (Table 1). Ultrasonography showed that the heart rate of first fetus was not observed and second one was active. Obstetrical examination revealed membrane bulging through cervical os with 3-cm cervical dilatation and regular uterine contraction with 2-minute interval. The authors had accomplished vaginal delivery of first fetus after spontaneous membrane rupture with foul odor amniotic fluid. The second fetus with breech presentation had arrest of second stage of labor. There was high clinical suspicion for chorioamnionitis and the status of the

patient was aggravated. Therefore, emergency hysterotomy under venovenous (VV) ECMO support was decided for therapeutic abortion. Second fetus was delivered without complication. Postoperatively, the norepinephrine dose was reduced and the vasopressin infusion was discontinued.

Case 2

A 37-year-old woman gravid 2 para 1 gave birth to a healthy infant at full term by vaginal delivery at local clinic. After delivery, she developed uterine atony unresponsive to oxytocin and had large amount of bleeding through vagina. She was transferred to the present hospital and her blood pressure was 60/40 mmHg and heart rate was 160 beats per minute. Laboratory data revealed severe disseminated intravascular coagulation (DIC), with a platelet count of $53 \times 10^3/mm^3$, 60 mg/dL of fibrinogen, 4.89 of prothrombin time international normalized ratio, unmeasurable activated partial thromboplastin time, 25% of antithrombin III activity, and 20 ug/mL of D-dimer. She required massive transfusion due to persisted atonic bleeding. Despite the transfusion, her systolic blood pressure remained at around 70 mmHg and an echocardiography showed severe diffuse hypokinesia of left ventricle (LV) with epinephrine, norepinephrine, and vasopressin. As well, she developed severe hypoxia despite full support of mechanical ventilation. To maintain stable vital sign and bridge to bleeding control, the authors initiated the venoarterial (VA) ECMO. Despite continuous use of transfusion and uterotonics, uterine atony was aggravated. So, she received hysterectomy and ligation of both internal iliac arteries under ECMO support. After surgery, she did not recover from the DIC. Her blood loss for the first day at the hospital was estimated to be 20,000 mL and she received 52 units of red blood cell concentrates, 40 units of fresh frozen plasma, and 40 units of platelet concentrates. After five days, she was successfully weaned from ECMO and tracheal extubation was performed three days after withdrawal of ECMO.

Revised manuscript accepted for publication June 19, 2017

Table 1. — *Baseline characteristics.*

Variable	Case 1	Case 2	Case 3	Case 4
Age, years	36	37	30	38
Pregnancy status	Pregnant (21 weeks)	Postpartum day 1	Postpartum day 1	Postpartum day 1
BMI, kg/m ²	22.1	19.7	32.5	30.82
APACHE II score	21	29	15	21
SOFA score	17	14	9	13
Lung injury score	4	3.75	4	4
Diagnosis	Septic shock due to chorioamnionitis	Hypovolemic shock due to atonic uterine bleeding	Cardiotoxicity due to epidural anesthesia	Cardiogenic shock due to amniotic fluid embolism
ECMO indication	ARDS	SCMP, ARDS	ECPR, SCMP, ARDS	ECPR, SCMP, ARDS
ECMO configuration	VV	VA->VV	VA->VV	VA->VV
Anticoagulation	No	No	No	No
Pre-ECMO blood gases				
PaO ₂ /FiO ₂ ratio	67	73	37	41
pH	7.32	7.02	6.93	6.9
PaCO ₂	25	26	38	80
Lactic acid	11.8	14.2	11.1	12.8
Hemodynamics				
MAP mmHg	45	42	40	35
EF (%)	50	40	10	13
Vasopressor requirement (mcg/min/kg)				
Norepinephrine	0.5	0.4	0.8	0.5
Epinephrine	10	0.1	0.2	0.1
Dopamine	0.04	8	5	10
Vasopressin (U/min)	N-A	0.04	0.04	0.04
Operation under ECMO	Emergency C-sec	Hysterectomy, ligation of both internal iliac arteries, coil embolization of left external iliac artery	Hematoma evacuation	Hematoma evacuation
Rescue therapies	Polymyxin hemoperfusion	N-A	N-A	N-A
Dialysis	Y	Y	Y	Y

ECMO: extracorporeal membrane oxygenation, BMI: body mass index, APACHE II score: Acute Physiology and Chronic Health Evaluation II score, SOFA score: Sequential Organ Failure Assessment score, ARDS: acute respiratory distress syndrome, ECPR: extracorporeal cardiopulmonary resuscitation, SCMP: stress induced cardiomyopathy, VV: venovenous, VA: venoarterial, MAP: mean arterial pressure, EF: ejection fraction, C-sec: caesarean section.

Case 3

A 30-year-old woman gravid 2 para 1 at 38 gestational weeks was admitted to emergency room of the hospital with cardiopulmonary resuscitation. She had suddenly become breathless and cyanotic after anesthesia injection via epidural catheter for elective cesarean section, due to previous cesarean delivery at local clinic. Oxygen saturation decreased to 40% and she developed hypotension. She was intubated promptly and placed on mechanical ventilation. After an emergency cesarean section, she was transferred to the present hospital. On arrival, she had a sudden cardiac arrest and cardiopulmonary resuscitation was re-attempted, along with infusion of vasopressors and inotropic agents. Echocardiography revealed LV global hypokinesia with severe dysfunction. For hemodynamic stabilization, VA ECMO was applied immediately. With the initiation of ECMO, her vital signs became stable, and most of the vasoactive medications were tapered gradually. After one day, the follow-up echocardiography revealed nearly normalized LV systolic function. Intra-abdominal hematoma was developed one day after and hematoma evacuation was performed (Table 2). On the 11th day, she was weaned off the ventilator due to recovery of lung function recovery, and after three days, she was weaned off the ECMO following stable

vital sign. On the 26th hospital day, she was discharged without neurologic complications.

Case 4

A 38-year-old woman gravid 2 para 2 had been admitted to the local clinic for repeated cesarean section. After three hours of cesarean delivery, her systolic blood pressure fell to 70 mm Hg, her pulse to 30 beats per minute, and oxygen saturation to 70%. The patient reported chest pain, and her lips became white; apnea developed rapidly thereafter, and she became unresponsive. The trachea was intubated, and transferred to the present hospital. During transfer, she developed sudden cardiac arrest, and cardiopulmonary resuscitation was begun. On arrival, VA ECMO was applied immediately, along with infusion of vasopressors and inotropic agents. The echocardiography revealed LV global hypokinesia with severe dysfunction. With the initiation of ECMO, the patient's vital signs became stable. Under a suspicion of amniotic fluid embolism, she was evaluated to rule out other major problems than amniotic fluid embolism. The chest computed tomography angiography revealed no pulmonary embolism, but showed diffuse haziness over both lung fields. After two days, the follow-up echocardiography revealed nearly normalized LV

Table 2. — *Clinical outcomes and complications.*

	Case 1	Case 2	Case 3	Case 4
Maternal survival	Y	Y	Y	Y
Fetal survival	N	Y	Y	Y
ECMO duration, days	9	6	13	10
Ventilator duration, days	10	9	10	50
Hospital stay, days	87	189	26	129
ICU stay, days	15	81	18	55
Bleeding complications	N	Hematoma	Hematoma	Hematoma
Neurologic outcomes	Normal	Normal	Normal	Cognitive dysfunction
Other complications	Fingertip amputation due to ischemia	N	N	N

ECMO: extracorporeal membrane oxygenation, ICU: intensive care unit.

function; however, she developed retroperitoneal hematoma and underwent hematoma evacuation. On the 10th day, the patient was weaned off ECMO. Although the patient was awake, she was unable to obey verbal commands. On the 129th hospital day, she was discharged with impaired cognitive function.

Discussion

Cardiopulmonary collapse in obstetric patients may be caused by various catastrophic situations including septic chorioamnionitis, massive obstetrical hemorrhage, epidural anesthesia, and amniotic fluid embolism. These situations are uncommon, unpredictable but very fatal. Until recently, there is no treatment option except conventional critical care such as mechanical ventilation and vasopressor. However, conventional treatment failed to maintain clinical stability and bridge to definite surgery or procedure. The chances of survival for these young patients were particularly low. To reverse refractory shock and hypoxia, ECMO was the only option as a bridge therapy to the definitive source control.

ECMO can be a useful rescue therapy in refractory shock of various causes. In the present cases, stress induced cardiomyopathy (SCMP) was successfully treated with VA ECMO. SCMP is one of common indication for ECMO support [4]. During peripartum period, SCMP is infrequent and usually has a self-resolving and benign course, but it can become a fatal complication requiring cardiac resuscitation in certain patients like in the present cases [5]. Although the use of ECMO remains still controversial in adults with refractory septic shock, ECMO might be a valuable therapeutic option in adult patients with refractory cardiac dysfunction [6]. ECMO can support decreased cardiac output in patients with the cardiogenic form of refractory shock which is unresponsive to very high doses of catecholamines [7]. In the previous report, the present authors showed that ECMO effectively bridged the time between refractory septic shock and recovery through infection control with antibiotics [8]. Even with high doses of catecholamines, the present patients (cases 1-4) were unable to maintain adequate cardiac contractility and oxygen deliv-

ery. ECMO enabled to control the infection source by delivery (case 1), to control the bleeding focus by hysterectomy and embolic therapy (case 2) and to bridging recovery of SCMP (cases 2-4).

Although much is unknown regarding the unique risks associated with ECMO in the peripartum and postpartum periods, concerns remain about both hypercoagulability and hemorrhage. For this reason, application of ECMO with hemorrhagic tendencies such as DIC requires careful consideration. However, the present authors extended the indication in obstetric patients who had no choice, although they have ongoing bleeding as a major contraindication. In the present patient (case 2), although uterine bleeding and DIC were required the control of the bleeding focus, severe hemodynamic instability disrupted the definite control of bleeding focus. Therefore, for bridging to definite therapy, ECMO was initiated to support cardiopulmonary support despite uterine hemorrhage and DIC.

Total bleeding complications during ECMO support developed in three patients (cases 2-4), it developed more frequently compared with the present authors' own institutional experience in non-obstetric patients, and more often than in recent report [9, 10]. The present authors tightly regulated the activated clotting time range between 130 and 150 seconds during hematoma evacuation under ECMO support and managed to complete the treatment without other major bleeding. Like the present cases, in patients receiving ECMO support without anticoagulation, blood clots are commonly encountered complication. However, recently, the improvement of ECMO technique reduced the amount of heparin needed, and successful experiences about heparin-free ECMO in patients with co-existing hemorrhage are reported [11-13]. It suggests that ECMO can be considered a rescue and bridge therapy in very unstable obstetric emergency with bleeding tendency. In the present authors' experience, all patients were supported by ECMO with favorable outcomes without anticoagulation. They conducted careful examination of the entire ECMO circuit and all their patients were weaned from ECMO as soon as possible to reduce the risk of thrombo-

sis.

Obstetric emergency can be unpredictable and rapid deteriorate despite conventional management. The careful multidisciplinary planning including extracorporeal support is an evolving concept of obstetric emergency. Thus, the obstetricians should consider early transfer to a specialized center in the selected patients in which ECMO has shown benefit in this case series. The early ECMO application by early notification for high risk obstetric patients who showed sudden collapse with requirement of mechanical ventilation or high dose of vasopressors could improve survival and neurological outcomes. In conclusion, ECMO has a role as rescue and bridge therapy in obstetric patients with unexpected refractory shock or hypoxia who would otherwise die of either hypoxemia or inadequate cardiac output.

Acknowledgement

This study was supported by a 2016 research grant from Pusan National University Yangsan hospital.

References

- [1] Itagaki T., Onodera M., Okuda N., Nakataki E., Imanaka H., Nishimura M.: "Successful use of extracorporeal membrane oxygenation in the reversal of cardiorespiratory failure induced by atonic uterine bleeding: a case report". *J. Med. Case Rep.*, 2014, 8, 23.
- [2] Benetis R., Nadisauskiene R., Sirvinskas E., Lenkutis T., Siudikas A., Kadusauskaite V., et al.: "Successfully treated severe obstetric sepsis and acute respiratory distress syndrome with extracorporeal membrane oxygenation". *Perfusion*, 2016, 31, 343.
- [3] Agerstrand C., Abrams D., Biscotti M., Moroz L., Rosenzweig E.B., D'Alton M., et al.: "Extracorporeal Membrane Oxygenation for Cardiopulmonary Failure During Pregnancy and Postpartum". *Ann. Thorac. Surg.*, 2016, 102, 774.
- [4] Yoo T.K., Lee J.Y., Sung K.C., Oh S.S., Song Y.S., Lee S.J., Ko K.J.: "Stress-induced cardiomyopathy presenting as shock". *J. Cardiovasc. Ultrasound*, 2016, 24, 79.
- [5] Wu E-T., Lin T-H., Lin C-H., Lee C.N.: "Left ventricular assist device for stress-induced cardiomyopathy after postpartum hemorrhage". *Taiwan J. Obstet. Gynecol.*, 2014, 53, 429.
- [6] Brechot N., Luyt C.E., Schmidt M., Leprince P., Trouillet J.L., Leqer P., et al.: "Venoarterial extracorporeal membrane oxygenation support for refractory cardiovascular dysfunction during severe bacterial septic shock". *Crit. Care Med.*, 2013, 41, 1616.
- [7] Maclaren G., Butt W.: "Extracorporeal membrane oxygenation and sepsis". *Crit. Care Resusc.*, 2007, 9, 76.
- [8] Yeo HJ, Jeon D, Kim YS, Cho WH, Kim D.: "Veno-veno-arterial extracorporeal membrane oxygenation treatment in patients with severe acute respiratory distress syndrome and septic shock". *Crit. Care*, 2016, 20, 28.
- [9] Sharma N.S., Wille K.M., Bellot S.C., Diaz-Guzman E.: "Modern use of extracorporeal life support in pregnancy and postpartum". *ASAIO J.*, 2015, 61, 110.
- [10] Nair P., Davies A.R., Beca J., Bellomo R., Ellwood D., Forrest P., et al.: "Extracorporeal membrane oxygenation for severe ARDS in pregnant and postpartum women during the 2009 H1N1 pandemic". *Intensive Care Med.*, 2011, 37, 648.
- [11] Wen P.H., Chan W.H., Chen Y.C., Chen Y.L., Chan C.P., Lin P.Y.: "Non-heparinized ECMO serves a rescue method in a multitrauma patient combining pulmonary contusion and nonoperative internal bleeding: a case report and literature review". *World J. Emerg. Surg.*, 2015, 10, 15.
- [12] Tomasko J., Prasad S.M., Dell D.O., Decamp M.M., Bharat A.: "Therapeutic anticoagulation-free extracorporeal membrane oxygenation as a bridge to lung transplantation". *J. Heart Lung Transplant.*, 2016, 35, 947.
- [13] Muellenbach R.M., Kredel M., Kunze E., Kranke P., Kuestermann J., Brack A., et al.: "Prolonged heparin-free extracorporeal membrane oxygenation in multiple injured acute respiratory distress syndrome patients with traumatic brain injury". *J. Trauma Acute Care Surg.*, 2012, 72, 1444.

Corresponding Author:

DONG-HYUNG LEE, M.D., PHD

Department of Obstetrics and Gynecology

Pusan National University Yangsan Hospital

Beomteo-ri, Mulgeum-eup, Yangsan

Gyeongsangnamdo, 626-770 (Republic of Korea)

e-mail: ldh0707@hanmail.net