

Case Report

Successful Use of Extracorporeal Membrane Oxygenation for Status Asthmaticus in a Woman With a Periviable Pregnancy

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BACKGROUND: Status asthmaticus is a severe asthma exacerbation with persistent airway obstruction despite standard therapy. Use of extracorporeal membrane oxygenation (ECMO) as rescue therapy in pregnancy is exceedingly rare. We describe a case of ECMO for treatment of status asthmaticus in woman with a periviable pregnancy culminating in a term delivery.

CASE: The patient was a 33-year-old woman, gravida 3 para 1, admitted at 23 2/7 weeks of gestation with respiratory failure secondary to status asthmaticus. Venovenous ECMO was initiated and continued for 6 days. After hospital discharge, she had no further respiratory issues. She ultimately developed fetal growth restriction and gestational hypertension and underwent a repeat cesarean delivery at 38 weeks of gestation.

CONCLUSION: Venovenous ECMO can be used successfully for status asthmaticus during a periviable pregnancy and enable delivery at term.

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Status asthmaticus, a rare phenomenon in pregnancy, is defined as a severe asthma exacerbation refractory to standard treatment. It may lead to sudden death, most commonly by severe bronchospasm with mucus plugging leading to asphyxia. The incidence

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Teaching Point

1. Venovenous extracorporeal membrane oxygenation is a life-saving treatment that can be used successfully for status asthmaticus in periviable pregnancies.

during pregnancy is not well-established, but exacerbations requiring hospitalization can be seen in more than 25% of women with severe asthma.¹ Status asthmaticus is treated with aggressive bronchodilator therapy, leukotriene receptor antagonists, systemic corticosteroids, and intubation when necessary. Extracorporeal membrane oxygenation (ECMO) refers to a modified cardiopulmonary bypass circuit used to provide temporary respiratory and cardiac support.² Successful application of venovenous ECMO as a rescue therapy for refractory status asthmaticus has been used outside of pregnancy; in pregnancy it has been described primarily for treatment of acute respiratory distress syndrome.² We describe a case of venovenous ECMO as rescue therapy for status asthmaticus in a woman with a periviable pregnancy, successfully culminating in a term delivery. This case reviews the indications for and mechanism of ECMO and demonstrates how ECMO can be used as a therapeutic option for pregnant women with status asthmaticus.

CASE

The patient was a 33-year-old woman, gravida 3 para 1, at 23 2/7 weeks of gestation, dated by last menstrual period consistent with a 22 6/7-week ultrasonogram, who was transferred from another hospital with hypercarbic respiratory failure secondary to status asthmaticus. Her medical history was significant for late entry to care, poorly controlled chronic asthma with regular marijuana use, and preeclampsia in her first pregnancy. The patient originally presented to the referring hospital with several days of shortness of breath after exposure to sick contacts and repeated marijuana use. Given the degree of tachypnea and accessory muscle use, bilevel positive airway pressure was initiated. Her white blood cell count was 16,900/microliter, and there was no infiltrate on chest radiograph. Despite albuterol every 2 hours, ipratropium every 6 hours, and 60 mg intravenous methylprednisolone twice a day, she had persistent difficulty with ventilation and was intubated and transferred by medical flight for ECMO.

On arrival to our institution, the patient immediately underwent a transthoracic echocardiogram in the cardiac catheterization laboratory, which demonstrated a possible



clot in the right pulmonary artery, a left ventricular ejection fraction of approximately 40%, a mildly dilated right ventricle with mildly reduced systolic function, and no major valve abnormalities. On arrival, her end-tidal CO₂ was 110, which improved to 45–50 after initiation of ECMO. Arterial blood gas showed normalization of her pH and PCO₂. After successful cannulation and initiation of venovenous ECMO, the patient was continued on ventilator settings, with a goal of maintaining the physiologic acid-base status of pregnancy. She was given therapeutic anticoagulation when ECMO was initiated as well as for empiric treatment for a possible pulmonary embolism seen on an echocardiogram.

While on the ventilator, the patient received 80 mg intravenous methylprednisone every 6 hours and continuous albuterol at 20 mg/h. She was started on vancomycin, cefepime, and azithromycin for broad-spectrum coverage. Ultimately, her sputum cultures noted *Moraxella catarrhalis* and bronchoscopy lavage cultures noted methicillin-sensitive *Staphylococcus aureus*, so she was transitioned to vancomycin and ceftriaxone. In addition, her respiratory panel was positive for influenza A and coronavirus, for which she completed a course of oseltamivir. Venovenous ECMO sweep was gradually weaned. Once oxygenation and ventilation were adequate after a few hours off any sweep gas, the patient was successfully decannulated (at 24 1/7 weeks of gestation, hospital day 6) and ultimately extubated at 24 4/7 weeks of gestation (hospital day 9). She was weaned to room air within 24 hours of extubation and was maintained with DuoNeb, inhaled steroids, and a prednisone taper.

Multiple interdisciplinary family meetings occurred while the patient was critically ill to decide on timing of fetal monitoring and intervention. Ultimately, the decision was made to proceed with antenatal corticosteroids starting at 24 5/7 weeks of gestation for fetal lung maturity and to begin fetal monitoring at 25 weeks of gestation. Although the patient remained stable from a cardiac perspective throughout the hospital course, we reviewed the scenario for a maternal cardiac arrest in our multidisciplinary meetings and concluded that no perimortem cesarean delivery would be performed if the patient were on ECMO to avoid the risk of catastrophic bleeding.

After hospital discharge, the patient had no further asthma exacerbations for the remainder of the pregnancy. She returned to her home institution for prenatal care. Of note, she developed fetal growth restriction and gestational hypertension at 37 5/7 weeks of gestation and underwent an uncomplicated repeat cesarean delivery at 38 0/7 weeks of gestation, with delivery of a 2,330-g boy with Apgar scores of 8 and 9 at 1 and 5 minutes, respectively. She received stress-dose steroids intrapartum and had an unremarkable postpartum course.

DISCUSSION

Per the Extracorporeal Life Support Organization, ECMO is reserved for patients with acute severe heart

or lung failure after conventional therapies fail. It is indicated in most patients with a mortality risk greater than 80% and may be considered in patients with a mortality risk greater than 50%³ and, ideally, in those anticipated to recover in a few days after ECMO support.² This patient was at high risk of a life-threatening asthma exacerbation given her smoking status and history of severe exacerbations. Given her persistent hypercapnia despite optimal conventional mechanical ventilation, and that her severe respiratory failure was potentially reversible, she was considered a candidate for ECMO support.

Extracorporeal membrane oxygenation creates a modified cardiopulmonary bypass circuit with venovenous ECMO providing temporary respiratory support and venoarterial ECMO providing both respiratory and hemodynamic support.^{2,4} Pulmonary support can be provided by venovenous ECMO, where venous blood is removed peripherally through the femoral vein or centrally through cannulation near the right atrium, oxygenated through an oxygen membrane, and returned to the venous system peripherally or centrally (Fig. 1). In venoarterial ECMO, venous blood is oxygenated and returned to the arterial system peripherally through the femoral artery or centrally through the ascending aorta (Fig. 1). Compared with venovenous ECMO, venoarterial ECMO is associated with an increased risk of thromboembolism, limb ischemia, and maldistribution of oxygen.⁴ For this reason, venovenous ECMO should be used for all cases of acute respiratory failure not complicated by cardiac failure.

In an ECMO circuit, carbon dioxide removal is determined by the inlet PCO₂, the blood flow rate, the sweep gas rate, and the membrane lung properties.³ Fresh air (sweep gas) is mixed with oxygen, and the sweep gas rate is set by the operator.² Extracorporeal membrane oxygenation is weaned using the lowest flow rate and sweep rate to provide adequate support. As in this case, if adequate ventilation and oxygenation can be maintained off sweep gas, the patient can be decannulated.

Pregnancy poses a unique technical concern during ECMO with caval compression by the gravid uterus, complicating adequate drainage of blood. In some cases, emergency delivery or placement of additional venous cannulas may be required before successful ECMO initiation.² With our patient, there were no issues with cannulation, and a slight left lateral tilt was used to successfully minimize venous compression from the gravid uterus. Importantly, patients on ECMO need to be anticoagulated to prevent clotting within the ECMO circuit and subsequent



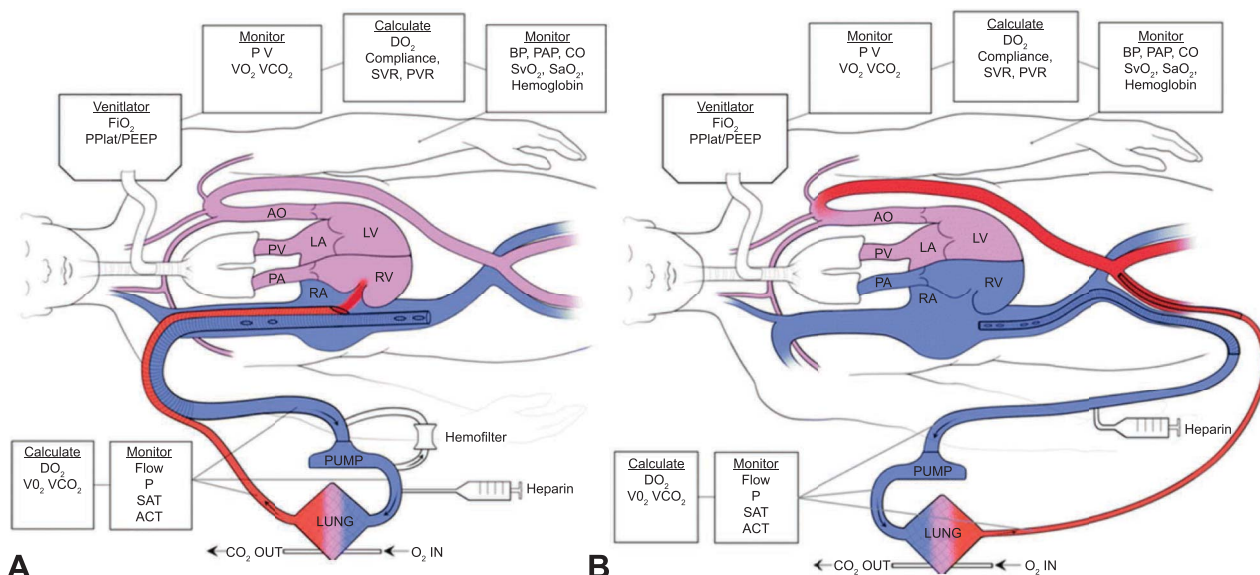


Fig. 1. Venovenous extracorporeal membrane oxygenation (ECMO) with bicaval drainage (A) compared with venoarterial ECMO with femoral-femoral access (B). FiO₂, fractional inspired oxygen; Pplat, plateau airway pressure; PEEP, positive end-expiratory pressure; P, pressure; V, volume; VO₂, oxygen uptake; VCO₂, carbon dioxide uptake; DO₂, oxygen delivery; SVR, systemic vascular resistance; PVR, pulmonary vascular resistance; BP, blood pressure; PAP, pulmonary artery pressure; CO, cardiac output; SvO₂, mixed venous oxygen saturation; SaO₂, arterial oxygen saturation; Sat, saturation; ACT, activated clotting time; CO₂, carbon dioxide; O₂, oxygen. Reprinted by permission from Springer Nature, Intensive Care Medicine, "Contemporary extracorporeal membrane oxygenation for adult respiratory failure, life support in the new era," MacLaren, G, A Combes, and RH Bartlett, Copyright 2012.

Clifford. ECMO for Status Asthmaticus in Pregnancy. *Obstet Gynecol* 2018.

thromboembolism. In the event of a cardiopulmonary arrest, the American Heart Association and Advanced Cardiac Life Support guidelines recommend cesarean delivery for any pregnancy of at least 20 weeks of gestation if spontaneous circulation has not returned within 4 minutes of cardiopulmonary arrest and ideally with delivery of the fetus within 5 minutes.⁵ However, these guidelines do not take therapeutic anticoagulation status into account, which could result in life-threatening hemorrhage and may hamper maternal resuscitation efforts.

A systematic review of ECMO use in pregnancy demonstrated maternal and fetal survival rates of 77.8% and 65.1%, respectively.⁶ The use of venovenous ECMO in pregnancy has been primarily described in cases of acute respiratory distress syndrome secondary to H1N1 infection.^{2,6} Only two cases have reported describing the use of venovenous ECMO for status asthmaticus in pregnancy (based on a PubMed search from January 1, 1950, to June 1, 2018, with the keywords "ECMO asthma pregnant," "ECMO asthma pregnancy," "ECMO status asthmaticus pregnant," "ECMO status asthmaticus pregnancy," "extracorporeal asthma pregnancy," "extracorporeal asthma pregnant"). The first case

described a patient at 25 weeks of gestation who received 60 hours of ECMO and spontaneously delivered at 31 weeks of gestation.^{7,8} The second case described a patient at 5 weeks of gestation who received ECMO for 48 hours and ultimately delivered at term.^{7,8} Our case describes the longest duration of venovenous ECMO for status asthmaticus in pregnancy, 6 days in duration, and ultimately culminating in a term delivery. Furthermore, our case adds to the existing body of literature illustrating the therapeutic utility of ECMO for the treatment of status asthmaticus in pregnancy.

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