Extracorporeal Membrane Oxygenation for Cardiopulmonary Failure During Pregnancy and Postpartum

Cara Agerstrand, MD, Darryl Abrams, MD, Mauer Biscotti, MD, Leslie Moroz, MD, Erika B. Rosenzweig, MD, Mary D'Alton, MD, Daniel Brodie, MD,* and Matthew Bacchetta, MD, MBA*

Division of Pulmonary, Allergy and Critical Care Medicine, Department of Medicine, Columbia University College of Physicians and Surgeons/New York-Presbyterian Hospital, New York; Department of Surgery, Columbia University College of Physicians and Surgeons/New York-Presbyterian Hospital, New York; Division of Maternal-Fetal Medicine, Department of Obstetrics and Gynecology, Columbia University College of Physicians and Surgeons/New York-Presbyterian Hospital, New York; Division of Pediatric Cardiology, Department of Pediatrics, Columbia University College of Physicians and Surgeons/New York-Presbyterian Hospital, New York; and Division of Cardiothoracic Surgery, Department of Surgery, Columbia University College of Physicians and Surgeons/New York-Presbyterian Hospital, New York, New York

Background. **Extracorporeal membrane oxygenation (ECMO) has been used with increasing frequency to support pregnant and postpartum patients with severe cardiac or pulmonary failure, although patient management and clinical outcomes are underreported. This study represents patients who received ECMO during the peripartum period.**

Methods. **All pregnant or postpartum patients treated with ECMO in the medical intensive care unit between January 1, 2009, and June 30, 2015, were included in this study. Data were analyzed retrospectively. The primary objective was to characterize the circumstances and clinical characteristics of the patients who received ECMO, describe our management during pregnancy and at the time of delivery, evaluate maternal and fetal outcomes, and report bleeding and thrombotic complications.**

Results. **Eighteen peripartum patients were treated with ECMO during the study period; 4 were pregnant at the time of cannulation. Median age was 32.6 years, and median gestational age in pregnant patients was 32 weeks. Sixteen patients (88.9%) survived to hospital discharge. Fetal survival was 14 (77.8%) in the entire cohort and 100% in patients cannulated after fetal viability. Two patients successfully delivered on ECMO. Bleeding complications developed in 6 patients (33.3%) and were associated with disseminated intravascular coagulation. No fetal complications were attributed to ECMO.**

Conclusions. **ECMO can be used during pregnancy and postpartum with favorable maternal and fetal outcomes, and it outweighs the risk of bleeding or thrombotic complications when managed by an experienced, multidisciplinary team.**

(Ann Thorac Surg 2016;■:■–■)

Extracorporeal membrane oxygenation (ECMO) has been used with increasing frequency in recent years to treat patients with severe cardiac or pulmonary failure [1, 2]. The development of safer, more durable devices, the widespread use of ECMO during the 2009 influenza A(H1N1) pandemic, and the publication of the CESAR (conventional ventilatory support versus extracorporeal membrane oxygenation for severe adult respiratory failure) trial have contributed to its worldwide growth [2–5]. Although the overall use of ECMO has increased, the outcomes of specific patient populations managed with ECMO remain underreported. One such area is the use of ECMO during pregnancy and postpartum.

The extent of published experiences with ECMO during and immediately after pregnancy is limited to case reports and small case series [6–10]. Much is unknown about the unique risks associated with ECMO in the peripartum period, although concerns have arisen about both hypercoagulability and hemorrhage. Likewise, the preferred method and timing of fetal monitoring and delivery are not well described. No current guidelines are available from the Extracorporeal Life Support Organization, the American College of Obstetricians and Gynecologists, or the Society for Maternal-Fetal Medicine on the use of ECMO during or after pregnancy. We report our institutional experience in the management of peripartum patients with ECMO. Our aim is to characterize the circumstances for which a patient received ECMO, describe our management practices during pregnancy

Accepted for publication March 2, 2016.

*Drs Bacchetta and Brodie are co-senior authors.

Address correspondence to Dr Brodie, Division of Pulmonary, Allergy and Critical Care Medicine, Department of Medicine, Columbia University College of Physicians and Surgeons/New York-Presbyterian Hospital, 622 W 168th St, PH 8-101, New York, NY 10032; email: hdb5@cumc.columbia.edu.

Published by Elsevier

0003-4975/$36.00
http://dx.doi.org/10.1016/j.athoracsur.2016.03.005

Abbreviations and Acronyms

APACHE = Acute Physiology and Chronic Health Evaluation
ARDS = acute respiratory distress syndrome
ECMO = extracorporeal membrane oxygenation
ECPR = extracorporeal cardiopulmonary resuscitation
DIC = disseminated intravascular coagulation
DVT = deep vein thrombosis
FIO_2 = fraction of inspired oxygen
ICU = intensive care unit
IQR = interquartile range
$PaCO_2$ = partial pressure of arterial carbon dioxide
PaO_2 = partial pressure of arterial oxygen

and at the time of delivery, and report maternal and fetal outcomes.

Material and Methods

All patients who were pregnant or up to 6 weeks postpartum and received ECMO in the medical intensive care unit (ICU) at New York-Presbyterian Hospital/Columbia University Medical Center from January 1, 2009, to June 30, 2015, were included in this study. Data were collected retrospectively from our institution's electronic medical record and are reported as median with interquartile range (IQR) or number with percentage unless otherwise specified. This study was approved by the Columbia University Institutional Review Board and performed in accordance with accepted ethical standards.

The decision to initiate ECMO was at the discretion of a multidisciplinary team that consisted of thoracic surgeons and medical intensivists. All patients with acute respiratory distress syndrome (ARDS) were classified as severe according to the Berlin definition [11]. At our institution, ECMO is considered in patients with ARDS when the ratio of partial pressure of oxygen in arterial blood (PaO_2) to fraction of inspired oxygen (FIO_2) is less than 80 mm Hg, pH is less than 7.15 in the setting of uncompensated hypercapnia, or the plateau airway pressure is greater than 35 to 45 cm of water, depending on body habitus and despite optimal ventilator management [12]. Our center has a robust ECMO transport program; hence, timing of ECMO and patient management before ECMO often reflect the clinical decisions and resources at referring institutions [13]. Patients who underwent extracorporeal cardiopulmonary resuscitation (ECPR) were either already admitted to our institution or experienced cardiac arrest at referring hospitals, after our mobile ECMO transport team was deployed for ARDS.

Patients who received venovenous ECMO were cannulated with a dual-site configuration with drainage from the right or left femoral vein and reinfusion to the right or left internal jugular vein, or with a bicaval dual-lumen cannula positioned in the right internal jugular. Patients who received venoarterial or venoarterial-venous ECMO were cannulated with femoral venous drainage and femoral artery reinfusion, with the return blood flow split between the femoral artery and internal jugular vein in situations of venoarterial-venous ECMO. Our ECMO circuits were either a Rotaflow centrifugal pump (Maquet Inc, Rastatt, Germany) and Quadrox D oxygenator or a CARDIOHELP system (Maquet Inc). To minimize hemolysis and thrombus development, we do not use a bridge, and we minimize access ports within the circuit. In patients who received ECMO for ARDS, our center uses a blood conservation protocol that includes a transfusion threshold of hemoglobin less than 7.0 g/dL and titration of intravenous heparin infusion to an activated partial thromboplastin time between 40 and 60 seconds [14]. We screen for upper and lower extremity deep vein thrombosis (DVT) in all patients after decannulation.

Pregnant patients were closely followed by our institution's high-risk maternal-fetal medicine service. Fetal monitoring included twice daily fetal heart tones or nonstress tests and pelvic ultrasound scans. All patients with viable fetuses received steroids to support fetal lung development before delivery.

Results

Eighteen patients were treated with ECMO during the study period. Median age was 32.6 years (IQR, 26 to 39) and Acute Physiology and Chronic Health Evaluation II score was 27 (IQR, 23 to 30) (Table 1). Fourteen patients (77.8%) were postpartum and 4 (22.2%) were pregnant while receiving ECMO. Gestational age of pregnant patients was 29.1 weeks (range, 18.4 to 34.3 weeks). Postpartum patients delivered 3 days (IQR, 1 to 6 days) before cannulation. Other baseline demographic and clinical characteristics are detailed in Table 1. Indications for ECMO included pneumonia with ARDS (n = 17), ECPR (n = 3), pulmonary embolism (n = 2), amniotic fluid embolism (n = 2), and pulmonary hypertension (n = 1). Several patients had multiple indications for ECMO, including 2 with ARDS who underwent ECPR, 1 with an amniotic fluid embolism who underwent ECPR, and 1 with a massive pulmonary embolism that developed into an amniotic fluid embolism after emergent cesarean delivery (Table 1).

Before ECMO, patients were endotracheally intubated for a median of 1.5 days (IQR, 1 to 3 days). Pre-ECMO arterial blood gas data showed a median PaO_2 to FIO_2 ratio of 53 mm Hg (IQR, 38 to 62 mm Hg), pH of 7.2 (IQR, 7.1 to 7.3), and partial pressure of arterial carbon dioxide ($PaCO_2$) of 52 mm Hg (IQR, 40 to 60 mm Hg) with median positive end-expiratory pressure of 12 cm of water (IQR, 10 to 15 cm of water) and FIO_2 of 1.0. Additional rescue therapies used before ECMO included neuromuscular blocking agents and inhaled pulmonary vasodilators (Table 1). Twelve patients (66.7%) had a reduced left ventricular ejection fraction, with a median of 37.5% (IQR, 20% to 46%). Sixteen patients (88.9%) were in shock.