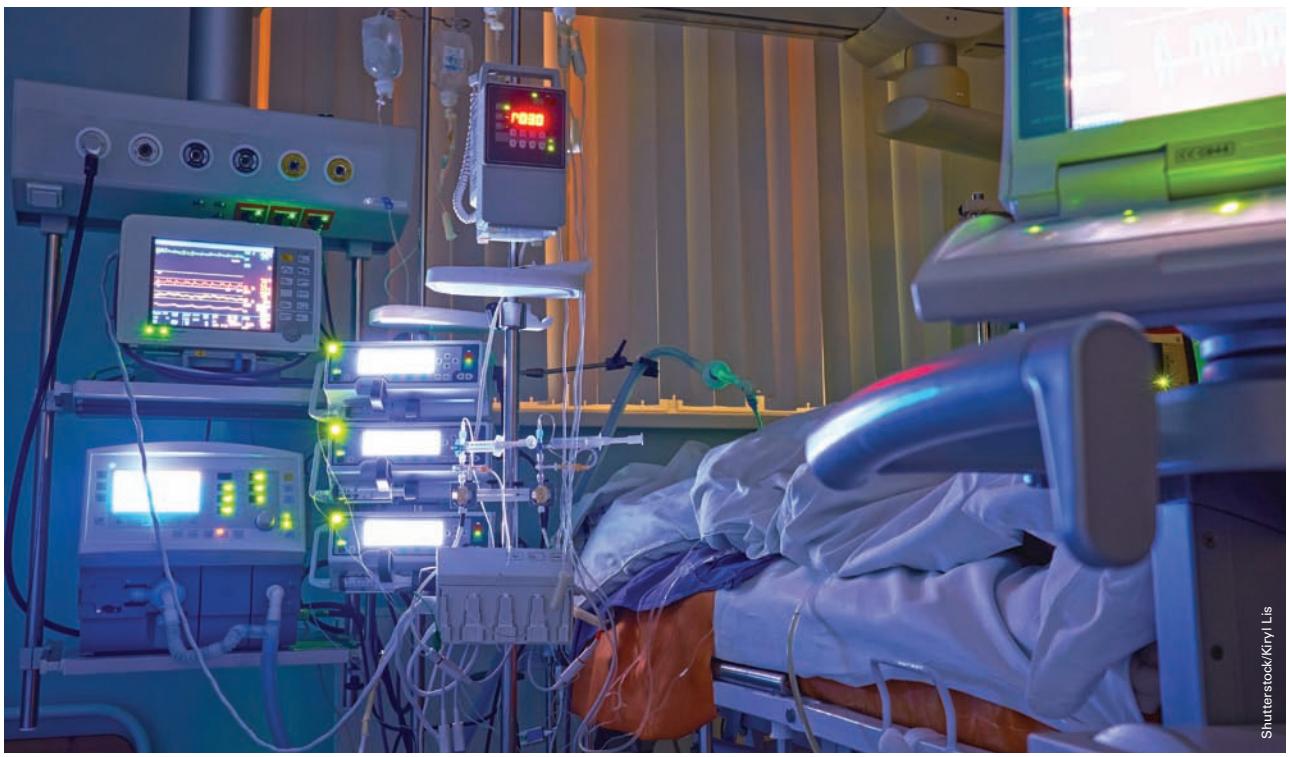
NCPD 2.5 ANCC Contact Hours


Shutterstock/Kiryl Lis

EXTRACORPOREAL CARDIOPULMONARY RESUSCITATION FOR AMNIOTIC FLUID EMBOLISM: REVIEW AND CASE REPORT

Courtney Stanley Sundin, MSN, RNC-OB, C-EFM, Laura Gomez, BSN, RNC-OB, and Brian Chapman, BS, RRT-ACCS-NPS

Abstract

Amniotic fluid embolism (AFE) is a rare, sudden, and catastrophic complication of pregnancy that can result in cardiopulmonary arrest, potentially leading to death. The pathophysiology of an AFE includes an inflammatory and coagulopathic response due to fetal materials entering maternal circulation with the hallmark triad of symptoms: acute respiratory distress, cardiovascular collapse, and coagulopathy. Management of AFE should include high-quality cardiopulmonary resuscitation, immediate delivery of the fetus if applicable, early intubation to provide adequate oxygenation and ventilation, fluid volume resuscitation, and ongoing evaluation of coagulopathy. Priorities include thromboelastography interpretation if available, control of hemorrhage and coagulopathy with blood component therapy, and cardiovascular support through inotropes and vasopressor administration. More recent approaches include implementing the A-OK (atropine, ondansetron, and ketorolac) protocol for suspected AFE protocol, extracorporeal cardiopulmonary resuscitation (ECPR), and extracorporeal membrane oxygenation (ECMO) therapies to increase survival and decrease complications. Venoarterial ECMO is the highest form of life support that provides support in patients with pulmonary and cardiac failure. ECPR is the application of Venoarterial ECMO during cardiopulmonary resuscitation in cases where the cause of arrest is believed to be reversible. Early implementation of ECPR during the acute phase of AFE can provide support for end-organ perfusion in place of the weakened and recovering heart while optimizing oxygenation, making venoarterial ECMO an ideal adjunctive therapy. Because of the rarity of AFE, many obstetrical teams may have limited prior experience in managing these catastrophic cases; however, with ongoing education and simulation, teams can be better prepared in the recognition and management of these life-threatening events.

Key words: Amniotic fluid; Cardiopulmonary resuscitation; Disseminated intravascular coagulation; Embolism; Extracorporeal membrane oxygenation; Pregnancy complications.

Amniotic fluid embolism (AFE) is a rare, sudden, and catastrophic complication of pregnancy that can result in cardiopulmonary arrest potentially leading to death (McBride, 2018; Sara et al., 2022). This occurs when fetal material, amniotic fluid, or trophoblasts enter the maternal circulation (Combs et al., 2021; Sara et al., 2022). The pathophysiology of AFE includes an inflammatory and coagulopathic response due to fetal materials entering maternal circulation (Viau-Lapointe & Filewod, 2019). In the United States, based on data from the National Inpatient Sample of 14.6 million hospital births from 2016 to 2019, the incidence of AFE was 6 in 100,000 births (Mazza et al., 2022). Maternal mortality due to AFE has been found to be between 10% and 17% and neonatal mortality ~6% (Mazza et al., 2022; Stafford et al., 2020). Stafford et al. (2020) stratified incidence of AFE by race and ethnicity as 70% non-Hispanic White women, 7% Hispanic women, 3% Asian women, 1% African American women, and 19% unspecified race or ethnicity. Diagnosing AFE is challenging because it is an exclusionary diagnosis and symptoms of AFE overlap with many other obstetric complications (Stafford et al., 2020). Increasing awareness of signs and symptoms and timely treatment of AFE among nurses, midwives, physicians, respiratory therapists, and other members of the perinatal health care team is crucial for early recognition, appropriate treatment, and optimal outcomes. A multidisciplinary approach is essential to decrease maternal and neonatal morbidity and mortality (McBride, 2018).

A multidisciplinary approach is essential to decrease maternal and neonatal morbidity and mortality.

Clinical Overview

Pathophysiology

Although the etiology of AFE is unknown, it is thought when fetal cells enter the maternal circulation, the fetal cells act as an antigen, triggering an abnormal immune response, including activation of proinflammatory mediators, a release of cytokines, and pro-coagulant factors resulting in the cascade of a multisystem collapse (Mazza et al., 2022; Sara et al., 2022). Pulmonary vasculature constricts, leading to acute pulmonary hypertension, progressing to right ventricular failure and pulmonary edema, hypoxemia, uterine atony, and finally hemorrhage with disseminated intravascular coagulation (DIC; Gitman et al, 2019; Sara et al., 2022). Some cases have reported a complication of maternal hypoxic encephalopathy (Viau-Lapointe & Filewod, 2019).

Signs, Symptoms, and Clinical Manifestation

The hallmark triad of AFE includes acute respiratory distress, cardiovascular collapse, and coagulopathy (Mazza et al., 2022). In all reported cases, the patient was hypotensive; other signs and symptoms include fetal heart rate abnormalities, dyspnea, loss of consciousness, bleeding, uterine atony, seizure-like activity, altered mental status, and sudden hypoxia (Gitman et al., 2019; McBride, 2018; Stafford et al., 2020). A review of the AFE registry found that over 70% of all AFE cases were women induced with oxytocin and 80% of all cases were women who gave birth via cesarean (Stafford et al., 2020). Incidence of AFE increases in circumstances such as cesarean birth, placental accreta spectrum disorder, placenta previa, and placental abruption (McBride, 2018). The severity of placental involvement with placental accreta spectrum disorder mirrors the association with AFE, increasing the risk as placental depth of invasion increases (Mazza et al., 2022). It is thought the disruption in the maternal–fetal barrier that occurs with placental abnormalities facilitates exposure and entrance of fetal material into maternal circulation. Other risk factors include advanced maternal age, cervical tears, manual removal of the placenta, induction of labor, abortion, amniocentesis, and maternal abdominal trauma (McBride, 2018; Stafford et al., 2020). Emerging evidence supports a genetic link between AFE and an overactive immune response (Mazza et al., 2022; McBride, 2018; Stafford et al., 2020). In approximately 66% of AFE cases, there is a history of atopy, which is characterized by asthma and food, drug, or latex allergies (Mazza et al., 2022; Stafford et al., 2020). As research continues, it will be important to explore the role of the maternal immune system and atopy related to the incidence of AFE.

Diagnosis

AFE should be considered as a differential diagnosis for all cardiopulmonary arrests of peripartum patients (Seong et al., 2018). Diagnosis historically has been made on autopsy; however, recent research has found this to be inaccurate due to fetal cells found on autopsies of those without a clinical presentation of AFE (McBride, 2018). A diagnosis can be made after considering the clinical presentation and excluding the following differential diagnoses: postpartum hemorrhage, eclampsia, uterine rupture, placental abruption, embolism, aspiration, acute myocardial infarction, shock, dissecting aortic aneurysm, local anesthetic toxicity, and high spinal block (McBride, 2018). The coagulopathy associated with AFE helps to distinguish it from the above differential diagnoses.

To facilitate consistency among researchers reporting on AFE, McBride (2018) suggests the following criteria must be met for diagnosis: (1) sudden onset of cardiopulmonary arrest or hypotension with respiratory compromise, (2) DIC, (3) onset of symptoms must occur during labor or within 30 minutes of delivery of placenta, and (4) afebrile. Atypical presentations of AFE can occur when some, but not all, of the previous criteria are met and cannot be explained by any other diagnosis (Stafford et al., 2020).

Treatment

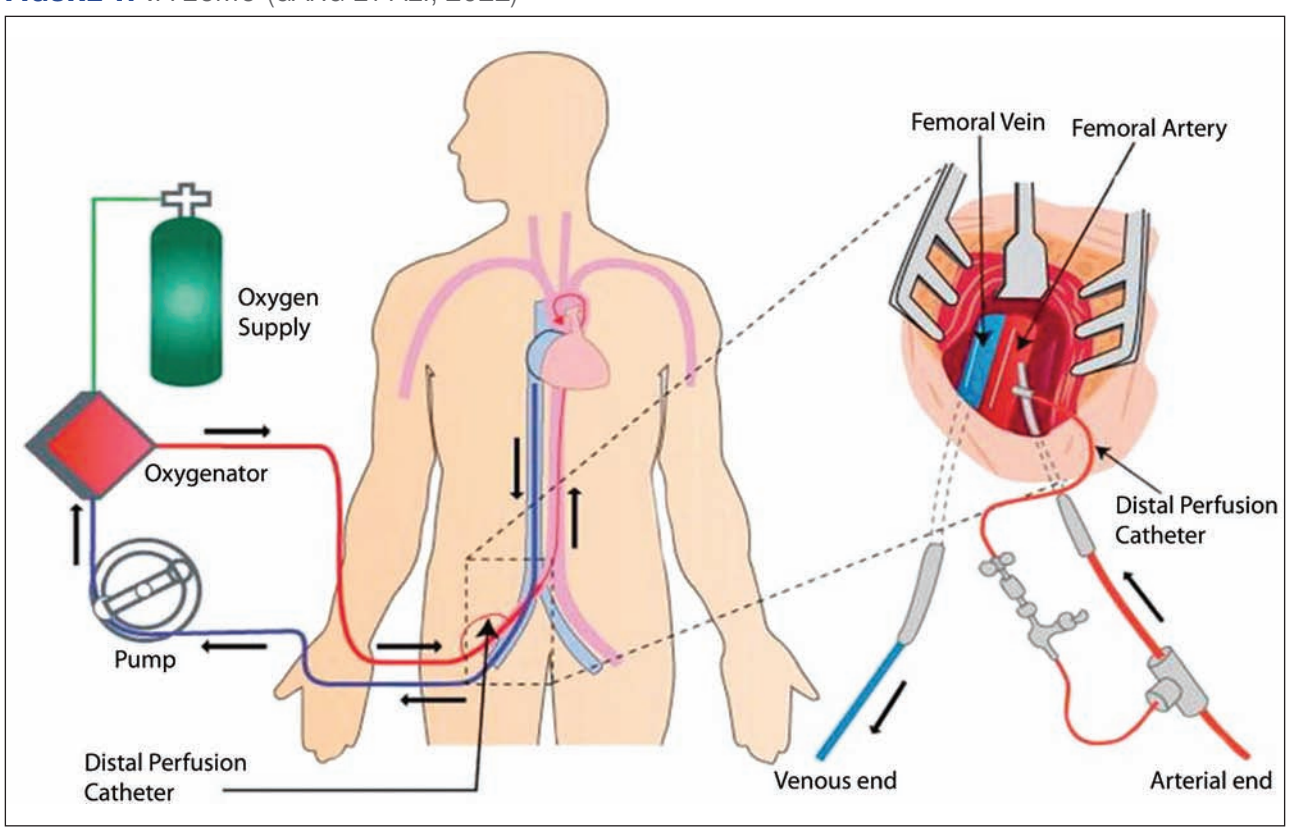
Management of AFE includes high-quality cardiopulmonary resuscitation, immediate delivery of the fetus if applicable, early intubation, fluid volume resuscitation, ongoing evaluation of coagulopathy with thromoboelastography (TEG) interpretation, control of hemorrhage and coagulopathy with blood component therapy, and cardiovascular support through inotropes and vasopressor administration. If an AFE occurs during labor prior to birth, expedited delivery through a resuscitative hysterotomy must be initiated promptly to prevent an anoxic brain injury to the fetus and improve circulation to the mother (Jeejeebhoy et al., 2015; Seong et al., 2018). More recent approaches include implementing the A-OK (atropine, ondansetron, and ketorolac) for suspected AFE protocol, extracorporeal membrane oxygenation (ECMO), and extracorporeal cardiopulmonary resuscitation (ECPR) therapies to increase survival and decrease complications (Gitman et al., 2019).

The A-OK AFE protocol involves administration of a combined therapy of atropine 0.2 mg, ondansetron 8 mg, and ketorolac 30 mg to address the potential underlying mechanisms of an AFE (Gitman et al., 2019). Atropine and ondansetron act to counteract effects leading to bradycardia, decreasing pulmonary hypertension and increasing peripheral vascular tone (Long et al., 2022). Ketorolac working as a non-steroidal anti-inflammatory aids in reversal of coagulopathy by inhibiting thromboxane (Long et al., 2022). Due to the rarity of AFE, validation of this regimen has not been completed, and consideration of this approach could lead to benefits established in retrospective published cases (Long et al., 2022).

Transesophageal echocardiography (TEE) can aid in diagnosis and treatment by evaluating ventricular performance and can guide resuscitation (McBride, 2018). This diagnostic test can also be used to help manage fluid resuscitation by monitoring the function of the right ventricle, ensuring the patient is not being fluid overloaded, further distending the right ventricle (McBride, 2018). Repeating TEEs throughout treatment allows the treatment team to monitor the progress of cardiac improvement to guide decisions regarding ECMO weaning and decannulation. Once TEE reveals cardiac improvement, early decannulation has been shown to lessen the complications associated with prolonged ECMO cannulation (Gitman et al., 2019).

Extracorporeal cardiopulmonary resuscitation ECPR is the application of Venoarterial ECMO during cardiopulmonary resuscitation in cases where the cause of arrest is believed to be reversible. VA ECMO supports both the cardiovascular and the respiratory system by removing deoxygenated venous blood, hyper-oxygenating the blood while simultaneously removing carbon dioxide by using a membrane oxygenator, and returning the oxygen-rich blood to the arterial system (Figure 1).

FIGURE 1. VA ECMO (GARG ET AL., 2022)



Compared to conventional cardiopulmonary resuscitation, ECPR more effectively stabilizes patients by providing oxygenated blood to organs and tissues, allowing providers more time to reverse the underlying cause of arrest, which gives the weakened heart time to heal while still providing adequate end-organ perfusion through VA ECMO (Abrams et al., 2022). Initiation and management of ECMO is completed by a specialized team of health care providers referred to at this facility as the ECMO team. This team includes a cardiothoracic surgeon, respiratory therapist, and registered nurse. Location of initiation of ECPR will be completed at the location the code is taking place. Survival rates of peripartum cardiac arrests have been found to improve with ECPR from 59% to 87% and survival rate for AFE from 52% to 85% (Naoum et al., 2020; Viau-Lapointe & Filewod, 2019). Early implementation of VA ECMO during the acute phase of AFE can provide end-organ perfusion while optimizing oxygenation, making VA ECMO an ideal adjunctive therapy (Viau-Lapointe & Filewod, 2019). Use of ECMO circuitry traditionally requires use of anticoagulation therapy to decrease risk of thrombosis; however, AFE patients are at very high risk for bleeding and developing DIC (Sara et al., 2022). Point of care TEG testing offers the opportunity for an assessment of coagulopathies through graphic interpretation (Sara et al., 2022). This allows for a rapid visualization of clot formation abnormalities and clotting factor levels to guide blood transfusion management (Sara et al., 2022). Interdisciplinary discussion with anesthesia, obstetrical, and intensive care teams about the balance of anticoagulation and bleeding risk must occur (Gitman et al., 2019; Seong et al., 2018). Initiating VA ECMO may be more beneficial than the potential risk in certain situations (Sara et al., 2022).

Amniotic Fluid Embolism Survival Outcomes

After surviving these catastrophic events, 55% of AFE survivors reported consistent depression and posttraumatic stress disorder (PTSD) with long-term complications, such as thyroid and liver dysfunction (Stafford et al., 2020). Subsequent pregnancies and recurrence of AFE was not found in literature and in a recent study, uncomplicated pregnancies and births occurred (Sara et al., 2022; Stafford et al., 2020). As research continues to expand on patient outcomes, few details are emerging about morbidity after survival. More research is needed to understand long-term outcomes and morbidity and suggests the need for a multidisciplinary approach in helping survivors with complications following discharge.

Exemplar Case Presentation

A 33-year-old woman, gravida 3 para 1 at 34 weeks and 2 days gestation reported to the obstetric emergency department located in the labor and delivery unit complaining of new-onset contractions occurring every 5 minutes and vaginal bleeding that was heavier than it has "ever been before," including a palm-sized clot, that began 6 hours prior to arrival. Past medical and surgical history included hypothyroidism, chronic hypertension, history of a myomectomy 8 years prior, a cesarean birth 2 years prior which required a blood transfusion, and allergies to stone fruits. She had two large uterine fibroids measuring 17 centimeters (cm) and 22 cm. The placenta was partially implanted on one of the fibroids. She had a history of vaginal bleeding during this pregnancy which was attributed to the uterine fibroids. The first episode occurred at 25 weeks gestation, and she was admitted to antepartum for 4 days to be monitored and complete a dose of betamethasone for fetal lung development.

Admission vital signs were blood pressure 114/58 mmHg, heart rate 100 bpm, oxygen saturation 99%, respiratory rate 18 breathes per minute, and temperature 98.2 °F. External fetal heart rate monitoring revealed a category II tracing with contractions every 1–2 minutes, and variable decelerations. Upon exam, she was 1 cm dilated and continued frank vaginal bleeding was noted and an orange-sized clot was evacuated during the sterile speculum exam by the provider. A bedside ultrasound revealed the fetus to be in breech position and with an

TABLE 1 LABORATORY VALUE TREND DURING HOSPITALIZATION

	Hemoglobin (g/dL)	Hematocrit (%)	Platelets (K/uL)	Partial Thromboplastin Time (seconds)	Fibrinogen (mg/dL)	D-Dimer (ug/mL)
Admit @1500	10.4	32.6	239	25.7	531	
CVICU @1845	10	31.3	102	62.3	61	>128.0
PP #1	8.8	26.8	104	25.7	212	
PP #2	8.3	25.3	107	26.5	392	
PP #3	7.7	23.3	108	-	-	
PP #4	7.8	24.2	144	-	-	
PP #5	9.0	27.7	158	-	-	
PP #6	10.5	30.9	210	-	-	
Day of discharge	11.6	35.8	239	-	-	

Key: PP, postpartum; CVICU, cardiovascular intensive care unit

anterior placenta. Based on assessment of vaginal bleeding and fetal monitoring, there was high suspicion for placental abruption and the team moved forward with an emergency cesarean birth.

Peripheral intravenous (IV) access was established, laboratory blood work was drawn, and blood products were ordered and placed on hold. Initial admission laboratory results included: white blood cell count of 10.0 k/uL, hemoglobin 10.4 g/dL, hematocrit of 32.6%, platelet count of 239 k/uL, aPTT 25.7 seconds, and fibrinogen 531 mg/dL (Table 1). She was transferred to the women's operating room at 1600 where a spinal epidural was placed, and surgery started at 1623. At 1630, the uterine incision was made, and the placenta was encountered at the incision site causing profuse placental bleeding. The patient immediately arrested, with no prodromal symptoms or complaints, with profuse uterine bleeding. No pulse was palpated, and the cardiac monitor reflected asystole. The baby was delivered at 1630 in frank breech presentation with Apgar scores of 8 at 1 minute and 8 at 5 minute while maternal chest compressions were initiated. The second anesthesia provider at bedside escorted the patient's husband from the OR and took him to the patient's room. A labor and delivery nurse sat with him until the chaplain arrived. The placenta was delivered manually, and the uterine and abdominal cavities were closed with suture.

During the initial resuscitation, the cause was suspected to be AFE due to abrupt onset; therefore, the A-OK protocol was ordered by the obstetrician. The cardiac rhythm remained in asystole and the patient was intubated at 1635. The code team arrived, and intensivist took over leadership of the code interventions from the anesthesia team. Code interventions continued with one unit of packed red blood cells (PRBCs) administered at 1637 and atropine 0.2 milligram (mg) administered at 1639. Return of spontaneous circulation occurred at 1640; however, shortly after the patient suffered another episode of cardiac arrest and chest compressions resumed. Epinephrine was administered at 1646 and the second unit of PRBCs was initiated at 1647. Chest compressions were held for pulse check at 1647 and pulse return was noted.

Her cesarean incision site was closed at 1650 and ECMO began to be initiated by a cardiothoracic surgeon and specialized ECMO team members who responded per policy with code blue initiation in women's service lines. The patient suffered another episode of cardiac arrest at 1655. Rapid cannulation and initiation of VA ECMO occurred at 1658 under ultrasound guidance via a 23 French (Fr.) venous drainage cannula in the right femoral vein with a 16 Fr. arterial return cannula in the right femoral artery. A 7 Fr. distal reperfusion sheath was placed in the superficial femoral artery under ultrasound guidance to adequately perfuse the right lower limb. For anticoagulation, 5,000 units of heparin were administered during ECMO cannulation. Upon initiation, ECMO flows ranged from 2.5 to 3.0 liters per minute.

Because of the rarity of amniotic fluid embolism, many obstetrical teams may not have prior experience in managing these catastrophic cases; however, with ongoing education and simulation, teams can be better prepared in recognition and management of these life-threatening events.

The initial ECMO flows were lower than calculated ideal ECMO flows due to hypovolemia from massive blood loss but using the ECMO circuit for rapid transfusion of PRBCs and fresh frozen plasma (FFP) paved the way for adequate ECMO flow that still provided end-organ perfusion in this case. An arterial line was placed by a certified registered nurse anesthetist at 1702 for invasive blood pressure monitoring and blood gas evaluation. A palpable pulse returned at 1704 and mean arterial pressure ranged from 65 to 70 mmHg. A TEE performed at 1705 revealed normal left ventricular ejection fraction (LVEF 60%) but a dilated right atrium and ventricle with mildly depressed right ventricular function, consistent with an AFE. A third unit of PRBCs was transfused at 1707, followed by a fourth unit at 1712. Point-of-care blood gases were run before and after cannulation, showing improvement (Table 2). Milrinone 2 mg IV was administered to increase myocardial contractility and a central venous access device was placed at 1715 by the anesthesiologist in the right jugular vein. The dressing was applied to the cesarean incision at 1742, quantitative blood loss during the case was 2561 mL, and the patient was transported to radiology for a pan scan CT at 1810 per facility protocol to investigate potential causes of cardiac arrest.

On arrival to the cardiovascular intensive care unit (CVICU) at 1845, laboratory results were reviewed and found to be consistent with DIC: PT 15.5 sec, PTT 62.3 sec, fibrinogen 61 mg/dL, d-dimer >128.0 micrograms per milliliter (ug/mL), H&H 10/31, and PLT 102 (Table 1). Coinciding with the laboratory results, the patient's TEG mapping and results showed clotting factor deficiency with low fibrinogen and function (Figure 2). Additional FFP and cryoprecipitate were ordered to treat clotting deficiencies. The patient's husband was escorted

TABLE 2 POINT OF CARE ARTERIAL BLOOD GAS RESULTS

Time	pH	pCO_2	paO_2	HCO_3	BD
1714	7.08	60	344	17.8	-12
1741	7.36	41	87	23.5	-2

Key: pCO_2, partial pressure carbon dioxide; paO_2, partial pressure oxygen; HCO_3, bicarbonate; BD, base deficit

to the CVICU by the chaplain where he waited outside her room and received updates from the nurses and physicians on the patient's status. The patient became acutely tachycardic and profuse vaginal bleeding was noted. The obstetric team was called to bedside. On assessment, the fundus was boggy and +4 above the umbilicus. The abdominal dressing was completely saturated and changed. The patient was treated with methylergonovine and misoprostol at 1939, carboprost at 1941 and 1958, and a uterine vacuum device was placed. Following uterotonics and vacuum device placement, vaginal bleeding improved, and hourly blood loss was measured with the suction canister. Additional blood loss in the CVICU was 2,450 mL, giving a cumulative blood loss of 5,011 mL. In total, the patient received 17 units of PRBCs, 7 units of FFP, 3 units of platelets, 7 units of cryoprecipitate, and 2,750 mL of albumin. Throughout the night, vital signs stabilized, ECMO flows were maintained between 2.5 and 3.0 L/min, and the patient remained sedated.

On postpartum (PP) day 1, a bedside repeat TEE showed cardiac function improvement, so the process for ECMO decannulation began. The patient was transported to the operating room and decannulated at 1319. An additional TEE was performed following decannulation and showed no significant change from the previous assessment of cardiac function. The patient's bleeding was stable; therefore, the OBGYN physician removed the uterine vacuum device at 1829 with scant vaginal bleeding. The patient was able to be weaned from sedation and extubated on PP day 2. Oxygen saturation after extubation was 94% on 4 liters nasal cannula. Obstetrically, the patient's bleeding remained stable with scant bleeding and a firm, midline fundus below the umbilicus. The patient and her husband verbalized the desire to breastfeed. A consult to lactation services was placed and lactation consultants assisted the patient in pumping every 3 hours while admitted and performed breast assessments. The patient was able to visually track and respond to name

FIGURE 2. THROMOBOELASTOGRAPHY (TEG) RESULT

Interpretation: CK: assessment of enzymatic, platelet, and fibrinolytic functions. CRT: clotting factors and clot strength. CKH: differentiation between coagulopathy and presence of heparin. CFF: assessment of fibrinogen (Sato et al., 2020).

but exhibited transient encephalopathic behavior evidenced by altered mental status and combative behavior. Ativan and Haldol were given to manage the restlessness and agitation.

By PP day 3, the patient was ambulating, received a visit from her baby (Figure 3), and social workers were consulted to offer emotional support. The patient's recovery was complicated by difficult to control hypertension, which required an esmolol infusion along with IV hydralazine and IV labetalol. Over the next few days, the patient continued to regain activities of daily living, resumed a regular diet, and was weaned off all respiratory support, with family member support at bedside. However, her mental status continued to fluctuate. At times the patient was oriented, but she would also experience periods of disorientation exhibited by confusion to her location and situation. Hypertension persisted and required the addition of a cardene drip to control blood pressure.

On PP day 4, blood pressure control improved, and the patient was transferred to the step-down unit. The next day, PP day 5, the patient was able to travel to the NICU to visit her baby by wheelchair with husband. The patient voiced concerns with fine motor control issues and brain fog, reported as difficulty with recollection. On PP day 6, the patient was discharged home with oral labetalol, physical therapy, and follow-up in 1 week. Patient had 30- and 60-day follow-up calls that showed her to be intact neurologically; however, she continued to have episodes of brain fog and lapses in memory prior to hospitalization.

Nine months later, the patient reports new-onset overactive parathyroid gland and Crohn's disease exhibited by rashes, joint pain, gastrointestinal disturbances, and temperature instability. She experienced delayed bonding with her baby due to initial separation and ongoing health complications, however, improved over a 6-month period. Additional reports of depression and PTSD for herself and family members were shared.

The team involved in the care of the patient during the cardiac arrest and resuscitation debriefed immediately following stabilizing the patient. A formal team debrief was conducted 2 days later to ensure all team members were able to attend and debrief again after having time to process the event. Those involved in the care and other members of the health care team were also supported through a "Code Lavender" after the resuscitation. At this facility, the chaplain department uses a "Code Lavender" to support team members who experience a difficult patient event which involves social-emotional support from the chaplain and sachets that contain a small bottle of lavender essential oil, chocolate, and an encouraging quote.

Clinical Implications

This case occurred at a large metropolitan, level IV maternal designated facility (American College of Obstetricians and Gynecologists & Society for Maternal-Fetal Medicine, 2019) with ~6,000 births per year in Fort Worth, TX. We recognize that the team at this facility is privileged to have access to a robust multidisciplinary team with advanced capabilities, such as ECPR initiation. Although all facilities that care for obstetric patients may not have access to these resources, they can increase their team's confidence and ability to care for patients affected by AFE by improving multidisciplinary teamwork, communication, emergency processes, and implementation of the A-OK protocol.

Because of the rarity of AFE, many obstetrical teams may not have prior experience in managing these catastrophic cases; however, with ongoing education and simulation, teams can be better prepared in the recognition and management of these life-threatening events. Frequent education updates with frontline clinical team members on management strategies and emerging medication therapy is necessary. Conducting simulation allows teams to practice working together and improve communication. Simulation can also help identify obstacles to multidisciplinary team management and aid in quality improvement by identifying barriers to safe care. It is vital to ensure all responding departments (blood bank, anesthesia, nursing, surgical technicians, physicians, ICU, and ECPR/ECMO teams) are involved in

FIGURE 3. THE MOTHER AND HER BABY IN THE CVICU ON POSTPARTUM DAY 3

Image used with permission.

CLINICAL IMPLICATIONS

- Creating and having access to emergency kits such as A-OK available to multidisciplinary teams facilitates rapid administration of medications targeting the cause of maternal arrest.
- The ability to assess coagulation status and activate massive transfusion protocols can help combat massive blood loss and hypovolemia during AFE events thus assisting in restoring hemodynamic stability.
- Use of VA ECMO as an avenue to transfuse PRBCs and FFP rapidly is often an overlooked benefit and can help prevent end-organ disfunction.
- Creating transport bags of ECPR supplies and ECMO machines to all areas outside of the typical intensive care setting can help facilitate early cannulation for VA ECMO at patient bedside during and following arrest.
- A few weeks prior to this event, the multidisciplinary team in this case simulated an ECPR maternal code scenario in the women's services operating room. After the simulation, several needs were identified and addressed prior to this case which contributed to the positive outcome for this patient. Multidisciplinary simulation on AFE can help identify potential barriers and improve team knowledge and response.
- Maternal and infant bonding is an important aspect of care when separation occurs. Nurses can facilitate bonding with transporting infants to patients or vice versa when able or providing updates, videos, and pictures when unable to be physically present.
- Nurses can support breastfeeding as per maternal condition and desires.
- Social worker consultations during hospitalization and recommendations for post discharge care can help with depression and PTSD following AFE events, aiding in patient recovery.

simulation and debriefing to allow for areas of improvement to be identified.

A few weeks prior to this event, the multidisciplinary team in this case simulated an ECPR maternal code scenario in the women's services operating room. After the simulation, several needs were identified and addressed prior to this case which contributed to the positive outcome for this patient. Our ICU, Code Blue, and ECMO teams created a transport bag for ECMO supplies that can be rapidly taken to any cardiac arrest in the facility. Labor and delivery nurses worked with pharmacists to create emergency kits for A-OK and ECMO initiation. Pharmacists program the automated medication dispensing system to allow an override dispense of a predetermined medication when these kits are selected. The A-OK kit consists of atropine 0.2 mg, ondansetron 8 mg, and ketorolac 30 mg. The ECMO initiation kit contains 15,000 units of heparin, 750 mL albumin, and 10–10 mL normal saline flush. The availability of emergency supplies and medications for immediate use is critical during these time-sensitive events. Massive blood transfusion protocols which are familiar to the multidisciplinary team and can be activated in a timely manner allow for rapid transfusion of blood products when AFEs are suspected. This can save precious time when combating massive hemorrhage and DIC that accompanies AFE. Education for nurses, respiratory therapists, midwives, physicians, and other members of the team about when and how to activate these emergency protocols allows for teams to be prepared when obstetrical emergencies occur. Another important aspect of placing patients on VA ECMO provides an avenue to rapidly transfuse PRBCs and FFP while simultaneously providing end-organ perfusion. Volume administration is often an overlooked aspect of ECPR and can assist in the management of a massive hemorrhage secondary to AFE. To ensure maternal-specific care in non-obstetric departments, obstetric nurses should remain at bedside during recovery periods to assist with ongoing evaluation and treatment of vaginal bleeding, fundal assessment, and obstetric-related concerns. The obstetric nurse is familiar with medications commonly used in obstetric emergencies and contraindicated medications in this patient population. The obstetric team remaining at bedside decreases delays in care.

As this case shows, infant bonding is an important aspect of care that needs to be provided during maternal and infant separation. If maternal and infant separation is unavoidable, due to infant or maternal acuity, nurses can provide pictures and frequent updates, and closed-circuit video monitoring can provide patients with a sense of connection with their infant. When appropriate, encouraging physical bonding and skin-to-skin is beneficial for both mom and infant. Because of the trauma that occurs during an AFE event and reported association with depression and PTSD, facilitating in-hospital social work and behavioral health consults during stay and providing patients and family post discharge mental health resources and follow-up care following discharge can be beneficial for short- and long-term recovery. ✣

Courtney Stanley Sundin is Quality and Simulation Specialist, Baylor Scott and White All Saints Medical Center, Fort Worth, TX. The author can be reached at Courtney-sundin@gmail.com

Laura Gomez is Nurse Professional Development Generalist, Baylor Scott and White All Saints Medical Center, Fort Worth, TX.

Brian Chapman is ECMO Program Coordinator, Baylor Scott and White All Saints Medical Center, Fort Worth, TX.

The authors declare no conflicts of interest.

DOI:10.1097/NMC.0000000000000970

References

Abrams, D., MacLaren, G., Lorusso, R., Price, S., Yannopoulos, D., Vercaemst, L., Bělohlávek, J., Taccone, F. S., Aissaoui, N., Shekar, K., Garan, A. R., Uriel, N., Tonna, J. E., Jung, J. S., Takeda, K., Chen, Y.-S., Slutsky, A. S., Combes, A., & Brodie, D. (2022). Extracorporeal cardiopulmonary resuscitation in adults: Evidence and implications. *Intensive Care Medicine*, *48*(1), 1–15. https://doi.org/10.1007/s00134-021-06514-y

American College of Obstetricians and Gynecologists & Society for Maternal-Fetal Medicine. (2019). Levels of maternal care (Obstetric Care Consensus No. 9). *Obstetrics & Gynecology*, *134*(2), e41–e55. https://doi.org/10.1097/AOG.0000000000003383

Combs, C. A., Montgomery, D. M., Toner, L. E., & Dildy, G. A. (2021). Society for Maternal-Fetal Medicine special statement: Checklist for initial management of amniotic fluid embolism. *American Journal of Obstetrics and Gynecology*, *224*(4), B29–B32. https://doi.org/10.1016/j.ajog.2021.01.001

Garg, P., Yazji, J. H., Alamouti-Fard, E., Wadiwala, I., Alomari, M., Hussain, W. A., Elawady, M. S. H., Masroor, S., & Jacob, S. (2022). Overview of venoarterial extracorporeal membrane oxygenation (VA-ECMO): Support for the management of cardiac arrest and cardiogenic shock. In *Management of shock: Recent advances* (pp. 1–36). IntechOpen. https://doi.org/10.5772/intechopen.105838

Gitman, R., Bachar, B., & Mendenhall, B. (2019). Amniotic fluid embolism treated with veno-arterial extracorporeal membrane oxygenation. *Case Reports in Critical Care*, *2019*, 1–4. https://doi.org/10.1155/2019/4589636

Jeejeebhoy, F. M., Zelop, C. M., Lipman, S., Carvalho, B., Joglar, J., Mhyre, J. M., Katz, V. L., Lapinsky, S. E., Einav, S., Warnes, C. A., Page, R. L., Griffin, R. E., Jain, A., Dainty, K. N., Arafeh, J., Windrim, R., Koren, G., & Callaway, C. W. (2015). Cardiac arrest in pregnancy: A scientific statement from the American Heart Association. *Circulation*, *132*(18), 1747–1773. https://doi.org/10.1161/CIR.0000000000000300

Long, M., Martin, J., & Biggio, J. (2022). Atropine, ondansetron, and ketorolac: Supplemental management of amniotic fluid embolism. *Ochsner Journal*, *22*(3), 253–257. https://doi.org/10.31486/toj.21.0107

Mazza, G. R., Youssefzadeh, A. C., Klar, M., Kunze, M., Matsuzaki, S., Mandelbaum, R. S., Ouzounian, J. G., & Matsuo, K. (2022). Association of pregnancy characteristics and maternal mortality with amniotic fluid embolism. *JAMA Network Open*, *5*(11). https://doi.org/10.1001/jamanetworkopen.2022.42842

McBride, A.-M. (2018). Clinical presentation and treatment of amniotic fluid embolism. *AACN Advanced Critical Care*, *29*(3), 336–342. https://doi.org/10.4037/aacnacc2018419

Naoum, E. E., Chalupka, A., Haft, J., MacEachern, M., Vandeven, C. J. M., Easter, S. R., Maile, M., Bateman, B.T., & Bauer, M. E. (2020). Extracorporeal life support in pregnancy: A systematic review. *Journal of the American Heart Association*, *9*(13), 1–15. https://doi.org/10.1161/JAHA.119.016072

Sara, D., Ahmed, K., Avraham, M., Dan, G., Nisim, I., & Idan, D. (2022). Life-threatening amniotic fluid emboli requiring massive blood transfusion and veno-arterial extracorporeal membrane oxygenation therapy: Case report and review of the literature. *Anesthesia & Pain Research*, *6*(1), 1–5. https://www.scivisionpub.com/pdfs/life-threatening-amniotic-fluid-emboli-requiring-massive-blood-transfusion-and-venoarterial-extracorporeal-membrane-oxygenation-the-2523.pdf

Sato, K., Katori, N., Suga, Y., Kiyama, S., & Uezono, S. (2020). Coagulation assessment with thromboelastography during abdominal endovascular aneurysm repair in a patient with hemophilia A. *JA Clinical Reports*, *6*(1), 7. https://doi.org/10.1186/s40981-020-0316-0

Seong, G. M., Kim, S. W., Kang, H. S., & Kang, H. W. (2018). Successful extracorporeal cardiopulmonary resuscitation in a postpartum patient with amniotic fluid embolism. *Journal of Thoracic Disease*, *10*(3), E189–E193. https://doi.org/10.21037/jtd.2018.03.06

Stafford, I. A., Moaddab, A., Dildy, G. A., Klassen, M., Berra, A., Watters, C., Belfort, M. A., Romero, R., & Clark, S. L. (2020). Amniotic fluid embolism syndrome: Analysis of the Unites States International Registry. *American Journal of Obstetrics & Gynecology MFM*, *2*(2), 100083. https://doi.org/10.1016/j.ajogmf.2019.100083

Viau-Lapointe, J., & Filewod, N. (2019). Extracorporeal therapies for amniotic fluid embolism. *Obstetrics & Gynecology*, *134*(5), 989–994. https://doi.org/10.1097/AOG.0000000000003513

For additional nursing continuing professional development activities on maternal-child topics, go to www.nursingcenter.com/ce

Lippincott® NursingCenter®

NCPD Nursing Continuing Professional Development

INSTRUCTIONS

Extracorporeal Cardiopulmonary Resuscitation for Amniotic Fluid Embolism: Review and Case Report

TEST INSTRUCTIONS

- Read the article. The test for this nursing continuing professional development (NCPD) activity is to be taken online at **www.nursingcenter.com/CE/MCN**. Tests can no longer be mailed or faxed.
- You'll need to create an account (it's free!) and log in to access My Planner before taking online tests. Your planner will keep track of all your Lippincott Professional Development online NCPD activities for you.
- There's only one correct answer for each question. A passing score for this test is 8 correct answers. If you pass, you can print your certificate of earned contact hours and access the answer key. If you fail, you have the option of taking the test again at no additional cost.
- For questions, contact Lippincott Professional Development: 1-800-787-8985.
- Registration deadline is March 7, 2025.

PROVIDER ACCREDITATION

Lippincott Professional Development will award 2.5 contact hours for this nursing continuing professional development activity.

Lippincott Professional Development is accredited as a provider of nursing continuing professional development by the American Nurses Credentialing Center's Commission on Accreditation.

This activity is also provider approved by the California Board of Registered Nursing, Provider Number CEP 11749 for 2.5 contact hours. Lippincott Professional Development is also an approved provider of continuing nursing education by the District of Columbia, Georgia, West Virginia, South Carolina, New Mexico, and Florida, CE Broker #50-1223. Your certificate is valid in all states.

Disclosure: The authors and planners have disclosed no relevant financial relationships regarding this educational activity.

Payment: The registration fee for this test is $24.95.