

Saved by ECMO

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The Case

A 27-year-old pregnant woman was admitted at an estimated gestational age (EGA) of 29 weeks for increased shortness of breath. She was diagnosed with severe pulmonary arterial hypertension and treated with pulmonary vasodilators and supplemental oxygen. At 36 weeks EGA, she was readmitted for elective cesarean delivery.

Lumbar epidural anesthesia was planned for the cesarean delivery. After the anesthesia provider inserted the epidural catheter, it was tested using 2 milliliters (ml) of 0.25% bupivacaine. After 5 minutes, an additional 3 ml of 0.5% bupivacaine was injected through the catheter. However, the patient suddenly became bradycardic and hypotensive. Within about 3 minutes, she developed pulseless electrical activity and cardiopulmonary resuscitation (CPR) began immediately.

The clinical team suspected inadvertent dural puncture with the epidural catheter, leading to total spinal block causing severe hypotension, right ventricular ischemia, and a pulmonary hypertensive crisis. Noradrenaline and vasopressin infusions were started and emergent cesarean delivery was performed. The patient had return of spontaneous circulation (ROSC) after two cycles of CPR, but she had another cardiac arrest. After six minutes of CPR, she had ROSC but then re-arrested after 4 minutes of spontaneous circulation. The anesthesia and perinatology teams decided to start veno-arterial extracorporeal membrane oxygenation (ECMO). Catheters were placed, and infusions of nitric oxide and trepostinil were started, with continuation of norepinephrine and vasopressin. The patient was transferred to the intensive care unit and was weaned off ECMO after five days. She was extubated after nine days in intensive care and survived without any neurological sequelae.

The Commentary

By Nicole A. Weiss, MD

Background

Severe pulmonary hypertension is associated with a high risk of morbidity and mortality in the peripartum period. Maternal mortality has been reported to be as high as 16-57%¹ and often occurs during delivery or in the immediate postpartum period as these patients are unable to tolerate normal physiologic changes. The pulmonary vasculature's inability to dilate prevents the right heart from meeting the increased oxygen demand as its output remains relatively fixed. This situation, in conjunction with increased plasma volume and decreased systemic vascular resistance (SVR) in the peripartum period, predisposes the patient to acute right heart failure. While patients with known pulmonary hypertension are generally counseled against pregnancy, many patients are unaware of their diagnosis and may present for the first time in their second or third trimesters with increasing shortness of breath. Despite treatment with medications and supplemental oxygen, these patients remain at high risk for peripartum complications. Any acute change in volume status, sudden loss of SVR, or increase in pulmonary vascular resistance (PVR) can lead to complete circulatory collapse.

A Systematic Approach to Improving Patient Safety

While the patient in this case ultimately had a good outcome, it represents a near miss. Neither the surgical team nor the anesthesia team appears to have planned for the possibility of circulatory collapse. Whether this lack of planning was due to underappreciation of the severity of the patient's disease, lack of knowledge of the risks involved, or overconfidence in their own skills is unclear; however, it led to prolonged cardiopulmonary resuscitation that put both the patient and her fetus at risk for serious complications.

Anticipating Anesthetic Complications

Providing anesthesia for patients with severe pulmonary hypertension can be challenging. Epidural anesthesia is often preferred as it avoids the increase in PVR that accompanies positive pressure ventilation and intubation. While there are many case reports of successful deliveries with neuraxial anesthesia,² this technique carries its own risks. An abrupt decrease in SVR (which is common with sympathectomy caused by neuraxial anesthesia) can lead to decreased right ventricular preload and circulatory collapse. While the use of an epidural catheter (as opposed to a spinal catheter) allows for slower titration of both the level of anesthesia and accompanying sympathectomy, there is always a risk of dosing too quickly or inadvertently puncturing the dura and getting what anesthesiologists call a "high spinal". The incidence of "high spinal" anesthesia varies in the literature and is largely unknown due to lack of reporting; however, a recent review reported it to be one of the most common complications of neuraxial anesthesia, occurring in 1 in 4336 administrations.³

While the choice of anesthesia in this case was appropriate and was likely the safest option, the anesthesia team failed to plan for what would happen if the SVR dropped too quickly. Even if the procedure had been done without causing dural puncture, patients with pulmonary hypertension require careful titration of pressors to offset the decrease in SVR caused by epidural anesthesia. This process can be challenging for even the most experienced anesthesia care providers as any miscalculation can result in hemodynamic instability. Thus, a plan for acute resuscitation and possible mechanical support should have been discussed prior to the procedure.

Planning for the Initiation of VA-ECMO

One of the biggest concerns in the management of this patient is the lack of preparation for, and the resulting delay in initiating, veno-arterial ECMO. While high quality CPR remains the gold standard for patients who suffer cardiac arrest,⁴ patients with severe pulmonary hypertension are less likely to regain spontaneous circulation from CPR alone. This is thought to be due to inability of external compressions to generate enough force to overcome elevated pulmonary arterial pressures. One study showed that only 23% of patients with pulmonary hypertension who underwent CPR developed ROSC.⁵ Another study reported a survival rate as low as 6%.⁶

In this patient, the efficacy of compressions and the ability to generate forward flow would have been even more limited given her advanced pregnancy. After twenty weeks gestational age, obstetric patients are at risk for aortocaval compression syndrome. To offset this compression, the American Heart Association recommends performing manual uterine displacement during CPR and proceeding to a perimortem cesarean delivery if ROSC is not achieved within four minutes. Both of these measures have been shown to increase the chance of restoring spontaneous circulation during CPR in the pregnant patient;⁴ however, in this patient's case, pulmonary hypertension was a complicating factor that would decrease the likelihood of sustained ROSC.

Given these factors and the patient's high risk for circulatory collapse, a plan for initiating VA-ECMO should have been in place prior to the patient's arrival to the operating room. VA-ECMO allows restoration of circulation and oxygenation when ROSC cannot be obtained with CPR. Patients with pulmonary hypertension have been shown to have survival rates of 16-50% when ECMO is utilized in the peripartum period.⁷

A Multidisciplinary Team

While the initiation of VA-ECMO can be life-saving, it requires both a skilled team and an extensive setup. Having both the personnel and equipment available in the operating room can save valuable time and improve patient outcomes; however, the organization of a standby team is impossible without multidisciplinary planning.

Recently, there has been a push for hospitals to develop a cardio-obstetrics team to coordinate care for pregnant patients with high-risk cardiac disease.⁸ While the composition of the team may vary across hospitals, most include multiple specialties, including maternal fetal medicine, cardiology, cardiac anesthesia, cardiac surgery, pulmonology, and critical care. Krishnan and colleagues suggest that patients with pulmonary hypertension should have 24/7 access to these services and be delivered at a hospital with the capability to provide advanced circulatory support.⁹

Had all of these specialties been consulted prior to the delivery, the need for possible mechanical support likely would have been recognized. Arterial and central venous lines could have been placed prior to the epidural and the cardiac surgery team could have been on standby in the room. This preparation would have allowed for rapid initiation of ECMO once the patient became unstable. With proper team planning, the prolonged run of CPR and emergent cesarean delivery could have been avoided.

Take Home Points

- All neuraxial anesthetics can trigger sympathectomy, which can be devastating in patients with pulmonary hypertension.
- Pregnant patients with severe pulmonary hypertension are at high risk for circulatory collapse in the peripartum period.
- CPR is unlikely to be effective at achieving return of spontaneous circulation in patients with severe pulmonary hypertension.
- A plan should be in place for rapid initiation of mechanical support in the event of circulatory collapse.
- A multidisciplinary cardio-obstetrics team should be involved in planning the procedure and potential complications should be discussed prior to the patient's arrival in the operating room.

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