

Anesthetic Management of a Simultaneous Emergency Craniotomy and Cesarean Delivery

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Fetal heart tone monitoring is a frequently used tool during nonobstetric maternal surgery to evaluate the immediate well-being of a fetus. We present a case of a parturient requiring an emergency craniotomy, during which fetal heart tone monitoring demonstrated fetal distress patterns. A simultaneous emergency craniotomy and emergency cesarean delivery proceeded

with favorable outcomes for both mother and infant. We present several issues associated with managing an emergent and concurrent maternal-fetal procedure.

Keywords: Cesarean delivery, concurrent surgery, craniotomy, fetal heart tone, monitoring.

Anesthesia for nonobstetric surgery in the parturient always carries the risk of fetal intolerance. Fetal heart tone (FHT) monitoring is a critical tool for the recognition of this intraoperative complication.¹ This case report describes a unique event that necessitated maternal and fetal surgical intervention simultaneously. Although a literature review identified several circumstances in which continuous anesthesia is used for sequential maternal-fetal procedures, there are few reports where concurrent emergency surgical intervention for both mother and fetus was performed.²⁻⁴ This report describes the management of a critically ill, nontrauma-related parturient who required an emergency craniotomy for repair of an arteriovenous malformation with subdural hematoma and, because of nonreassuring FHT tracings, required a simultaneous cesarean delivery.

Case Summary

The anesthesia department was notified by neurosurgical services of a 40-year-old parturient presenting to the emergency department (ED) by ambulance as a transfer from another facility. She had initially complained of a headache to family members before suddenly losing consciousness. On initial evaluation at the community hospital, she was unresponsive, hypertensive, and tachycardic, and had irregular respirations. The physician in the ED proceeded to provide airway protection by endotracheal intubation, but the initial attempts were unsuccessful. The transfer report indicated that, following several attempts at endotracheal intubation, an anesthesia provider was consulted and the airway was secured using a video laryngoscope (GlideScope, Verathon). The results of her laboratory testing were unremarkable. However, her computed tomography (CT) scan of the head demonstrated a large subdural hematoma. She was transported by ambulance from the community hospital to the refer-

ral hospital for neurosurgical intervention. It was noted in the transfer report that she was 24 weeks pregnant.

On arrival to the ED, the patient was responsive to pain, moving all 4 extremities, and was intermittently combative but had not developed any seizure activity. Her trachea remained intubated with continued mechanical ventilation. A CT angiogram demonstrated the presence of an extensive subdural hematoma extending along the left cerebral hemisphere, mild mass effect, an acute hematoma in the anterior left frontal lobe measuring approximately 2 × 3.3 cm, vasogenic edema, displacement of the frontal horn, and a 1.1 × 1.7 cm aneurysm secondary to an arteriovenous malformation (AVM). The decision was quickly made to perform an emergency craniotomy for evacuation of the subdural hematoma with resection or clipping of the AVM.

The patient was brought directly to the operating room (OR) while a simultaneous anesthesia evaluation was performed. Although her initial Glasgow Coma Score was 10, following the CT angiogram, her condition had deteriorated to a score of 7. Her husband was not present initially, and there was limited medical history. Documented findings included the following: previous general anesthesia without known complications; no indication of heart, lung, or kidney disease; gravida 9, para 8 status; a history of difficult airway; allergy to penicillin; and levothyroxine (Synthroid) as the only medication taken daily.

As the patient was brought to the OR, the obstetric (OB) team was notified that a 24-week parturient required neurosurgery and a request was made for continuous FHT monitoring and an OB consult. Fetal assessment in the ED had been performed by auscultation of heart rate. The fetal heart rate (FHR) was 152/min, and no fetal heart tracing was available. The patient was transported to the OR on a transport monitor and hand-ventilated on 100% oxygen with a bag valve mask. Left uterine displacement was maintained on the stretcher. An OB

team was present when the patient arrived in the OR and placed the external, electronic FHT monitor while the patient was being positioned. Although this was not a laboring patient and uterine contractions were not present, the cardiocography monitor was placed for continuous electronic FHR monitoring during the procedure as opposed to intermittent auscultation. She was transferred from the stretcher to the OR table, and the endotracheal tube was connected to the anesthesia circuit. Bilateral breath sounds, bilateral chest excursion, and end-tidal carbon dioxide (ETCO₂) tracings were confirmed. Standard monitors were applied. The patient's vital signs before induction were as follows: blood pressure, 118/67 mm Hg (mean, 84 mm Hg); heart rate, 95/min; and oxygen saturation, 96%. The sevoflurane vaporizer was set at 2.5% with oxygen fresh gas flow set to 2 L/min. Fifty micrograms of fentanyl and 5 mg of vecuronium were given intravenously (IV), and mechanical ventilation was initiated. The patient had 2 existing 18-gauge peripheral IV catheters. One peripheral IV catheter was attached to a Y-type blood set with normal saline (NS), and the other was attached to a standard (15 drops per milliliter) IV drip set with NS.

Following induction of anesthesia, systolic blood pressure decreased to 100 mm Hg. An infusion of phenylephrine was started to prevent a further decrease in blood pressure and was titrated to a mean arterial pressure of 85 mm Hg to maintain cerebral perfusion. In lieu of central venous access, an additional 16-gauge peripheral IV catheter was inserted while an arterial line was being placed. One liter of NS was rapidly infused after placement of the 16-gauge peripheral IV catheter. A blood sample for typing and crossmatching was sent to the blood bank, with a request to have 2 U of packed red blood cells sent to the OR immediately. Cefazolin, 2 g, was given IV after a negative test dose for prophylactic antibiotic coverage, according to the surgeon's request. Ventilation was optimized to an ETCO₂ of 25 to 30 mm Hg.^{5,6}

The patient's head was placed in Mayfield pins by the neurosurgeon. As the patient was being sterilely prepared and draped, the OB nurses monitored the FHR and advised that it remained acceptable in the 120/min to 130/min range but lacked beat-to-beat variability. At initial positioning and following placement of the head pins, the patient remained in left lateral tilt with uterine displacement for avoidance of aortocaval compression. Systolic blood pressure during this time was 120 to 140 mm Hg. Despite ongoing fluid replacement, the phenylephrine infusion was still being required to maintain baseline pressures. To supplement the infusion, ephedrine 10-mg boluses were administered.

Shortly after the neurosurgeon began the craniotomy, the OB team reported that the cardiocography monitor now demonstrated substantial FHR decelerations that were slow to return to baseline. The beat-to-beat vari-

ability remained absent. The obstetrician on site conferred with a second obstetrician to determine the best course for the fetus. Throughout the decelerations, maternal systolic blood pressure was 110 to 120 mm Hg, and her heart rate ranged from 90/min to 100/min. The inhalation agent was decreased from 2.6 to 2.2 end-tidal sevoflurane to minimize vasodilation and vasopressor requirements, ephedrine supplementation was continued, volume replacement continued, and left uterine displacement was again confirmed. Dexamethasone, 10 mg, and furosemide, 20 mg, were administered IV as requested by the surgeon to facilitate brain slackness.

Approximately 20 minutes after the initial craniotomy incision, after the dura mater had been opened, the FHR became bradycardic. A FHR of 70/min to 80/min was recorded for approximately 7 minutes. The return to baseline was greatly delayed at 11 minutes. During the deceleration, the obstetricians conferred with the neurosurgeon as well as a third fetal medicine expert and agreed to immediately begin an emergency cesarean delivery to prevent fetal demise. The neonatal intensive care unit (NICU) team was called and set up neonatal resuscitative equipment in the adjacent OR. Maintenance of the anesthetic was continued with a goal of stable baseline hemodynamics and normal oxygenation parameters.

Within 2 minutes of abdominal incision, a premature female neonate was delivered. Apgar scores were 3 and 3 at 1 and 5 minutes after delivery. It was reported to the neonatal team that fentanyl had been administered because the initial anesthetic plan did not involve delivery of the fetus. Because of prematurity, the neonate required mechanical ventilation, and endotracheal intubation was performed by the neonatal nurse practitioner before the infant was transported to the NICU in an isolette warmer.

The woman's abdomen was closed, and 30 U of oxytocin (Pitocin) was diluted into 500 mL of NS and infused over 15 minutes. Estimated blood loss from the cesarean delivery was approximately 300 mL. For the remainder of the craniotomy, the patient's fundus was massaged, and inspection was performed for bleeding at the surgical site and the vagina. At 1 hour and 45 minutes into the procedure, the craniotomy had resulted in 200 mL of blood loss, for a total blood loss of 500 mL, and urine output was 1 L. The patient was requiring more phenylephrine to maintain the preoperative baseline mean arterial pressure, and redistribution of fluids was suspected because isotonic crystalloid had been the fluid administered to this point. To support hemodynamic stability, a 500-mL bolus of 6% hetastarch in sodium chloride was administered.⁷

The remainder of the neurosurgical procedure progressed without major incident. The subdural hematoma was evacuated, and the arterial supply of the AVM was successfully clipped by the neurosurgeon. The craniotomy lasted approximately 2 hours. Total estimated blood loss was 600 mL, and 3,300 mL of NS and 500 mL

of hetastarch were given during the procedure. Following surgical closure, the decision was made to transfer the patient to the postanesthesia care unit (PACU) intubated with ventilator support despite spontaneous respirations and a 5-second sustained tetany without fade.

Within the hour, the patient's oxygen saturation had drifted to between 96% and 99% despite being on 2 L of oxygen fresh gas flow, and mild pulmonary edema was suspected. An additional 20-mg dose of furosemide was given IV to negate the effects of possible crystalloid overload. No difficulty in ventilation was identified after increasing the tidal volume from 7 mL/kg to 8 mL/kg and applying 5 cm H₂O of positive end-expiratory pressure. With these ventilator settings oxygen saturation was maintained at 99%. In addition to the uncertain neurologic status, the history of a known difficult airway guided the decision to avoid a trial extubation in the presence of possible pulmonary edema. Morphine, 10 mg, was titrated over several minutes while intraoperative laboratory studies were performed. These results included a glucose level of 179 mg/dL, hematocrit of 31%, and PaO₂ of 134 mm Hg. The patient was transferred to the recovery room with no vasoactive drips. Within 10 minutes of arrival to the PACU, the patient was following commands with all 4 extremities and mouthing words around the endotracheal tube.

After initial recovery from anesthesia, she was transferred to the surgical intensive care unit. She was extubated on postoperative day 1 after a pulmonary consult determined residual pulmonary edema had resolved. On postoperative day 4, she was visited in the hospital room and interviewed. She had no recall of the operative day. Her neurologic function was intact without deficit. She reported no anesthetic complications. On day 9, the patient was discharged, with no deficits. At the time of the interview, the neonate remained in the NICU. The infant had received surfactant soon after delivery and was supported by mechanical ventilation but was not displaying traumatic side effects common to premature infants such as intraventricular hemorrhage.

Discussion

Concurrent surgery for both parturient and fetus is rare.⁸ When emergency maternal surgery is warranted, the life of the parturient is the primary focus. This principle has even been applied to FHR monitoring. In fact, Horrigan et al⁹ suggested that in the absence of hypoxia, fetal heart monitoring resulted in no change in care. Despite the mother being the focus, it is standard practice to avoid risks to the fetus by avoiding maternal surgery when possible. Indeed the risks of general anesthesia, drug actions on the fetus, and the physiologic effects of surgery on the fetus often result in postponing maternal surgery until delivery is possible.^{1,10,11} This patient's life-threatening emergency required immediate surgical intervention,

while physiologic sequelae resulted in simultaneous cesarean delivery of the viable fetus. In some cases, a general anesthetic may be administered while the fetus is delivered, followed by the maternal surgery. This minimizes the effects of the surgery and drugs on the fetus. If deemed appropriate, the maternal surgery may proceed without a cesarean delivery, but with maternal heart rate and FHT monitoring. At the time of this case, there was a precedent in the literature for monitoring of FHT when possible during an emergency surgical procedure in the parturient.^{3,12,13} This noninvasive tool allows continuous evaluation of the fetus and correlates with the overall condition of the fetal oxygenation-perfusion status. Both the American Society of Anesthesiologists and the American College of Obstetricians and Gynecologists have established guidelines for when FHT monitoring should be employed during nonobstetric maternal surgery (Table).^{1,14} Although studies have found an increased incidence of unnecessary interventions such as cesarean delivery because of use of electronic fetal monitoring, most hospitals routinely employ this device.¹⁵

A search of published cases of simultaneous surgeries for parturient and fetus revealed very few results.¹⁶ Some cases involved a common anesthetic but involved a cesarean delivery followed by maternal surgery as opposed to concurrent procedures.^{3,17} Many of the cases were cardiothoracic in nature involving repairs of the aorta or coronary interventions due to complications of hypertension or as a result of trauma.^{18,19} Indeed, maternal hypertension was found to be an independent risk factor for complications of pregnancy. Additionally, advanced maternal age is also associated with complications of pregnancy. Although age greater than 45 years has been associated with increased risk of cesarean delivery and premature delivery, fetal health can be at risk with maternal age beyond 35 years as evidenced by low Apgar scores at birth.^{20,21} There were very few cases of unplanned neurosurgical intervention with concurrent cesarean delivery.^{2,3,4} In fact, pregnancy should not be considered a cause for delay in maternal neurosurgery.^{22,23,24}

As with most complex cases, adequate vascular access and invasive monitoring were keys to managing this case. The ability to closely monitor arterial pressure along with the ability to rapidly infuse fluids was vital. Although this patient did not require blood products, the neurosurgeon had stressed that he anticipated substantial blood loss and suggested preparation for blood transfusion. The use of isotonic crystalloids and colloids was based on the desire to avoid blood products completely. If blood had been required, the preference was to wait at least until after the fetus was delivered and the umbilical cord clamped. Blood compatibility with the fetus was of high importance, although in the presence of emergency surgery, the precedent is toward maternal stabilization first and subsequent management of the neonatal Rh

If the fetus is preivable

Measuring FHR by Doppler before and after the procedure is sufficient.

No currently used anesthetic agents at standard concentrations have been shown to be teratogens at any gestational age.

If possible, nonurgent surgeries should be delayed until the second trimester and elective surgeries should be delayed until after delivery.

A pregnant woman should never be denied indicated surgery, regardless of trimester.

FHR may be indicated intra-operatively to facilitate positioning or oxygenation interventions.

If the fetus is viable

Surgery should be done at a facility that has neonatal and pediatric services available.

Minimally, electronic FHR monitoring and contraction monitoring should be performed before and after the procedure to assess fetal well-being and the absence of contractions.

Continuous FHR monitoring should be used if it will not interfere with the primary surgery and if cesarean section could be performed.

The primary obstetrician for the patient should be notified, and if not available, an obstetrician with cesarean delivery privileges should be involved and ready to intervene if necessary.

If possible, when FHR is used, the woman should give informed consent to emergency cesarean delivery.

Table. ASA/ACOG Joint Recommendations on Nonobstetric Surgery During Pregnancy^{1,14}

Abbreviation: FHR, fetal heart rate.

factor concerns.²⁵ A second critical issue was the desired goal of decreased cerebral edema. The presence of a subdural hematoma with great potential for further bleeding warranted the minimization of excess cerebral flow while maintaining baseline perfusion pressures. Normal techniques for achieving this such as hyperventilation, corticosteroids, and diuretics had to be weighed against the potential harm to the fetus by way of decreased uterine blood flow. At several points during the case, maternal hypotension required the initiation of vasopressors to maintain baseline blood pressure. Despite the use of left uterine displacement and intravascular volume replacement, refractory hypotension required the use of phenylephrine. Although traditionally avoided because of the risk of decreased uterine blood flow, phenylephrine may actually be the antihypotensive agent of choice because of its fetal acid-base preservation characteristics.²⁶⁻²⁹ We were not able to determine whether the fetal bradycardia was caused by maternal neurologic sequelae, uterine perfusion, anesthetic influence, or other facets of the case. Although we could not correlate the use of phenylephrine (because of existing fetal bradycardia and FHR lack of variability) with fetal hypoperfusion, it could not be ruled out. The electronic FHR monitoring proved to be essential in determining fetal well-being, despite a seemingly satisfactory FHR previously documented.

A final key component to the successful outcomes in this case was clear communication between teams, both during surgery and postoperatively. Expert consultation was considered standard of care as we managed several specialized aspects of this patient's hospital course. Providers in neurosurgery, anesthesia, obstetrics, neonatology, and pulmonology all participated in this complex and dynamic case. The ability to access and utilize specialists in these disparate fields each ultimately delivered the reward of both mother and baby recovering without known complications. This case demonstrates the feasibility of a multidisciplinary approach to simultaneous

emergency procedures when the life of both mother and fetus are at risk.³⁰

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ACKNOWLEDGMENT

We thank Steve Starling, MD, for his guidance during this case and for his support of nurse anesthesia education.