

Anesthesia for Ex Utero Intrapartum Therapy (EXIT)

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A healthy 26-year-old gravida 2 para 1 female was referred for evaluation by her primary obstetrician after an 18-week ultrasound revealed fetal hydrops associated with enlarged lungs and dilated distal trachea. Magnetic resonance imaging (MRI) of the fetus confirmed a diagnosis of laryngeal atresia with no other apparent anomalies, and a diagnosis of congenital high airway obstruction syndrome (CHAOS) was made. A multidisciplinary team consisting of a pediatric surgeon, otolaryngologist, maternal fetal medicine (MFM) specialist, obstetric anesthesiologist, pediatric anesthesiologist, and neonatologist was assembled to review the case. All team members agreed that known laryngeal atresia made successful endotracheal intubation unlikely, and an ex utero intrapartum therapy (EXIT) procedure was deemed the most appropriate approach to delivery.

What Is an EXIT Procedure?

An EXIT procedure is a coordinated surgical procedure performed via cesarean delivery during which fetal oxygenation is maintained by the utero-placental circulation. These procedures are most commonly performed in fetuses with known congenital anomalies that are unlikely to have a successful transition from fetal to neonatal life without medical intervention. Common indications include airway, pulmonary, and cardiac abnormalities. An EXIT-to-airway procedure allows for placental oxygenation to continue while intubation and/or tracheostomy are attempted. An EXIT-to-resection procedure may be performed for pulmonary abnormalities while taking advantage of the ability to operate while on placental support, such as for resection of a congenital pulmonary mass. EXIT-to-ECMO (extracorporeal membrane oxygenation) allows for continued cardiopulmonary support after placental support is discontinued, such as for severe cardiac anomalies. Common indications

for each procedure are listed in Table 45.1. Advances in diagnostic and surgical techniques are rapidly expanding the list of indications for EXIT procedures, but the anesthetic principles and considerations remain largely the same.

How Are Patients Selected for an EXIT Procedure?

A mother and fetus are considered appropriate candidates for an EXIT procedure when the risk of extra-uterine death or disability to the fetus outweighs the risk of no prenatal intervention, and the risk to the mother is low. These patients should be evaluated by a multidisciplinary team, including pediatric surgeons, MFM specialists, obstetric and pediatric anesthesiologists, and neonatologists. Ideal patients are a mother with an otherwise uncomplicated pregnancy, and a fetus whose indication for surgery is an isolated defect. Relative contraindications include serious maternal comorbidities or the presence of multiple fetal congenital anomalies or a lethal genetic mutation.

What Should the Anesthesiologist's Preoperative Evaluation Include?

Maternal Preoperative Concerns

A thorough history and physical exam should be performed on the mother with special attention to medical comorbidities, pregnancy-related conditions, past abdominal or gynecologic surgeries, complications with general or neuraxial anesthesia, and information about previous deliveries. The anesthesiologist should be aware of any procedures performed during the pregnancy (e.g., cerclage, amnioreductions), as well as any current medications (e.g., tocolytics, antihypertensives, anticoagulation). Physical examination should focus on the cardiopulmonary system and an

Table 45.1 Common indications for EXIT procedure

Airway/Head and Neck anomalies (EXIT-to-airway)	Large cervical masses (cervical teratomas, cervical lymphangioma, large goiters) Retro-micrognathia/agnathia Congenital high airway obstruction syndrome (CHAOS)
Lung or mediastinal masses (EXIT-to-resection)	Congenital cystic adenomatoid malformation (CCAM) Bronchopulmonary sequestration Compressing mediastinal masses
Cardiopulmonary conditions EXIT to extracorporeal membrane oxygenation (ECMO)	Severe congenital diaphragmatic hernia Certain types of congenital heart disease

assessment of the back in preparation for placement of neuraxial anesthesia.

What Are the Fetal Preoperative Concerns?

For EXIT procedures, the fetus should be as close to term as possible, but some cases such as severe fetal hydrops may require an earlier procedure and delivery. Fetal genetic testing and imaging should be reviewed to ensure there are no contraindications to performing the procedure. The fetal anesthesiologist should be aware of fetal anomalies such as isolated limb abnormalities, as this may affect ease of obtaining IV access. Additionally, discussion with the MFM specialist should include assessment of placental location, fetal presentation, and estimated fetal weight, as these factors can alter the plan for surgical access as well as medication dosing.

The pediatric anesthesiologist's role perioperatively includes preparation of fetal resuscitation drugs, ensuring adequate fetal monitoring with pulse oximetry, administration of medications (intramuscular or intravenous), evaluating and/or managing the neonate's airway, as well as overseeing neonatal

resuscitation intraoperatively. In cases where surgical intervention is planned immediately after delivery (such as for resection of pulmonary masses), the pediatric anesthesiologist typically transports the neonate to an adjacent operating room to care for the baby during the procedure.

Describe the Logistical Concerns with an EXIT Procedure

EXIT procedures may occur in adult or pediatric hospitals, primarily based on local institution practices. Given the fact that the anesthesiologists are caring for both an adult and a fetus/neonate, it is not unusual that at least one of the anesthesiologists will find themselves in an unfamiliar environment with different institutional protocols regarding medication availability, transfusion medicine, and overall interdisciplinary teamwork and practices. As such, logistical planning should focus on familiarizing all involved anesthesiologists with the operating room setting, blood bank and pharmacy practices, and equipment and medications in order to minimize complications and delays with intraoperative resuscitation. For example, uterotonics may not be routinely available in a pediatric OR setting. All surgical steps and equipment as well as medications should be explicitly planned and evaluated prior to the procedure in order to identify potential logistic complexities before the day of surgery.

What Are the Maternal Anesthetic Goals?

While cesarean deliveries are typically performed under neuraxial anesthesia alone, EXIT procedures are most often performed using general anesthesia, typically with volatile anesthetics due to their ability to reliably decrease uterine tone.

Maternal goals include preservation of adequate utero-placental perfusion and maintenance of adequate uterine relaxation, typically achieved at volatile anesthetic concentrations of up to 2–3 times minimum alveolar concentration (MAC) of a pregnant woman. Concerns regarding fetal cardiac depression at these high levels of volatile anesthetic have led to increasing interest in the use of other techniques such as supplemental IV anesthesia (SIVA) or neuraxial anesthesia in combination with intravenous medication for uterine relaxation such as nitroglycerin. The patient should be positioned with left uterine displacement (15–30 degree tilt) to prevent aortocaval compression. Blood pressure

should be monitored with an arterial line, with the goal of maintaining maternal blood pressure at baseline, and end-tidal carbon dioxide should be maintained at physiological levels for pregnancy, approximately 30 mmHg. Large bore IV catheters may be advantageous for rapid fluid or blood administration.

The volatile anesthetic concentrations required to preserve uterine relaxation for the duration of the EXIT procedure may have the unintended consequence of also decreasing maternal mean arterial pressure (MAP) secondary to decreasing systemic vascular resistance. Uterine flow is not autoregulated, and as such, depends entirely on maternal blood pressure. Vasoactive infusions (most often phenylephrine) are routinely used to maintain adequate MAPs in the mother, thus maintaining perfusion of the utero-placental circulation. At the end of the procedure, the volatile concentration is decreased quickly to allow for adequate uterine tone.

What Are the Fetal Anesthetic Goals?

After hysterotomy, the fetus is exposed, typically allowing for access for echocardiography and to the surgical site and one extremity for pulse oximetry and IV placement. Covering the monitored extremity with foil to prevent interference from surgical lights can optimize the pulse oximetry cable waveform. The fetal anesthesiologist also administers medications as needed to facilitate surgery, including anticholinergic agents (e.g., atropine), muscle relaxants (e.g., vecuronium), and opiates (e.g., fentanyl).

Identify the Steps for Maternal and Fetal Resuscitation

Fetal oxygenation while on uteroplacental support is expected to be 50–70%. Fetal cardiac monitoring typically involves echocardiography to assess fetal heart rate and contractility and is typically performed by a cardiologist or MFM specialist. If abnormal values are observed in any of these metrics, the maternal anesthesiologist must ensure adequate uteroplacental perfusion by optimizing maternal MAP, oxygenation, and volume status. The surgeon should concurrently assess the surgical field for compression of the umbilical cord and palpate it to confirm adequate pulse.

During an EXIT procedure, both the obstetric and pediatric anesthesiologists should be prepared for maternal or fetal distress requiring resuscitation. Maternal hemodynamics should be supported with vasopressors, adequate left uterine displacement,

volume or blood replacement and 100% FiO₂. In the event of cardiopulmonary arrest, resuscitation should follow maternal cardiac arrest guidelines, ensuring 30-degree left tilt to relieve aortocaval compression, and emergent delivery of the fetus and abandonment of the EXIT procedure.

If the fetus is hypoxic or hypoperfused but the mother is stable, the fetal team should confirm adequate umbilical cord perfusion and follow the neonatal resuscitation algorithm, including administration of medications and chest compressions. If necessary, the EXIT procedure should be abandoned in favor of umbilical cord separation and continued postnatal resuscitation in the NICU.

Decreased cardiopulmonary reserve in the fetus means that instability may happen quickly, and successful resuscitation depends on excellent communication between surgical, anesthesia, and neonatal teams.

After separation of the infant and clamping the umbilical cord, uterotonics are administered, and the volatile anesthetics are discontinued in favor of an intravenous anesthetic technique. Local anesthetic and morphine are then administered through the previously placed epidural catheter.

What Postoperative Outcomes Should Be Expected in Mother and Baby?

As after all cesarean deliveries, the mother should be carefully monitored for postpartum hemorrhage and venous thromboembolism. A multimodal approach to surgical pain should be employed, including neuraxial opiates, local anesthetic via neuraxial or regional blocks (e.g., quadratus lumborum or transversus abdominis plane block), scheduled acetaminophen and nonsteroidal antiinflammatory drugs, and as needed oral or intravenous opioids.

Neonatal outcomes may be more complicated, and are usually related to the indication for the EXIT procedure. As a result of the procedure, these babies may have an artificial airway in place or require NICU support for other reasons specific to their intervention. Management of these patients should be tailored to the individual clinical scenario and led by the neonatal and pediatric surgical teams.

Case Resolution

At 37 weeks' gestation, the patient presented for surgery. After placement of two 16-gauge IVs and an

arterial line, aspiration prophylaxis was administered. A lumbar epidural was placed for postoperative analgesia. The patient was brought to the operating room, and general anesthesia was induced without complications. After uterine exposure, uterine relaxation was achieved with 3.8% sevoflurane, while a phenylephrine infusion was titrated from a starting dose of 0.5 mcg/kg/min to maintain MAPs at baseline.

Hysterotomy was performed with a stapling device, and the fetus' head, neck, and left upper extremity were exposed. The fetal anesthesiologist placed a fetal pulse oximetry probe to the left hand and then administered fentanyl 10 mcg/kg, vecuronium 0.4 mg/kg and atropine 20 mcg/kg intramuscularly to the fetus. The otolaryngologist attempted direct laryngoscopy and noted an imperforate laryngeal membrane that was not amenable to endotracheal intubation. A tracheostomy was then performed with colorimetric confirmation utilizing a carbon dioxide detecting device. The fetal heart rate was maintained in a range of 120–160 throughout the procedure, and after confirmation of

placement, the artificial airway was secured and the umbilical cord was clamped. Upon delivery, the neonate was passed to the neonatology team.

After delivery, the volatile concentration to the mother was rapidly decreased and oxytocin was administered via bolus followed by continuous infusion. Once surgical hemostasis was achieved, the epidural was bolused with 0.25% bupivacaine, 100 mcg fentanyl, and 3 mg preservative-free morphine, and the patient was extubated awake. The patient made adequate urine, estimated blood loss was 800 mL and no blood products were given.

On postoperative days one and two, the patient's epidural infusion was continued and she received scheduled acetaminophen and ibuprofen. On postoperative day two, the epidural was removed after a second dose of 3 mg preservative-free morphine was administered. The mother experienced no complications. The neonate remained stable in the NICU with tracheostomy in place with plans for delayed intervention by the otolaryngologists.

Suggested Reading

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