Lesson 320: Assessment and Management Of a Patient for the EXIT Procedure

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Read this article, reflect on the information presented, then go online and complete the lesson post-test and course evaluation before the termination date below. (CME credit is not valid past this date.) You must achieve a score of 80% or better to earn CME credit.

TIME TO COMPLETE ACTIVITY: 2 hours
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Professional Gaps

Due to increased use of sophisticated intrapartum monitoring and imaging studies, life-threatening abnormalities can be identified before birth. Although repair of these abnormalities is often restricted to tertiary care centers, initial stabilization, especially of the airway, may be required on an emergency basis. Thus, all anesthesiologists should have a basic understanding of the principles involved.

Learning Objectives

At the completion of the activity, the reader will be able to:

1. Define the goals of the ex utero intrapartum treatment (EXIT) procedure
2. List the common indications
3. Describe prenatal assessment and preoperative planning for the EXIT procedure
4. Identify the multidisciplinary team members involved
5. Describe the intraoperative anesthetic considerations for the EXIT procedure
6. Distinguish the conditions of the EXIT procedure from routine cesarean delivery
7. Discuss monitoring of maternal and fetal hemodynamic parameters
8. List the associated maternal risks
9. List the associated fetal risks
10. Review the effect of inhalational anesthetic agents on uterine tone

Case

A healthy, 28-year-old nulliparous woman was referred for a maternal-fetal medical consult after routine prenatal ultrasonography performed at 20 weeks’ gestation revealed anatomy suggesting obstruction of the oropharynx. Serial ultrasonography and ultrafast fetal magnetic resonance imaging performed at 32 weeks’ gestation confirmed polyhydramnios and complete upper airway obstruction by a large macrocystic mass of the oropharynx, parapharyngeal space, and maxilla. The patient and
father of the fetus met with members of the multidisciplinary fetal surgery team to discuss the prognosis and the maternal and fetal risks of delivery. The EXIT procedure was scheduled at 36 weeks’ gestation.

**Introduction**

The ex utero intrapartum treatment (EXIT) procedure is a highly specialized fetal operation in which uteroplacental circulation is preserved for surgical intervention until subsequent delivery. This procedure differs from cesarean delivery in its requirement of maximal uterine relaxation and maintenance of uterine volume. Although these uterine conditions also are critical for midgestational open fetal surgical procedures, including myelomeningocele repair, intentional delivery after fetal intervention is unique to the EXIT procedure. Introduced for the reversal or “unplugging” of tracheal occlusion performed in fetuses with severe congenital diaphragmatic hernia (CDH), the extended hemodynamic stability afforded by the EXIT procedure has been successfully adapted and applied to the management of a variety of potentially life-threating fetal conditions at the time of delivery.\(^2\)

One of the most common interventions performed during the EXIT procedure is securing the fetal airway. While hypoxemia and risk for hypoxic organ damage escalate after 5 minutes of unsuccessful attempts to establish a neonate airway postpartum, partial delivery with preserved uteroplacental circulation transforms an emergent situation with high morbidity into a controlled environment to manage an anticipated difficult airway.\(^3,5\)

Preceding the advent of the EXIT procedure are anecdotal reports of intrapartum fetal airway management after partial vaginal or cesarean delivery before clamping of the umbilical cord, but without measures to prevent uterine contraction or placental separation.\(^2,6\) In 1989, Norris et al reported the use of general anesthesia with halothane to provide uterine relaxation and maintain placental and umbilical blood flow during an attempt to secure a fetal airway obstructed by a large anterior neck mass.\(^7\) In 1996, Skarsgard et al described the successful endotracheal intubation of a partially delivered 36-week fetus with cystic hygroma during cesarean delivery under inhalational general anesthesia, as the “operation on placental support” procedure.\(^8\) Also in 1996, Mychaliska et al presented procedural guidelines for fetal airway management during preserved uteroplacental circulation as the EXIT procedure.\(^9\) The systematic approach introduced by Mychaliska et al for the reversal of tracheal occlusion in CDH also was applied to 2 fetuses diagnosed prenatally with cystic hygromas of the head and neck. The successful techniques and outcomes specific to this approach over the last several years, many in instances in which the indication is an opportunity to treat an isolated fetal anomaly, have made the EXIT procedure one of the more commonly performed fetal surgeries today.\(^4,6\)

**Indications for the EXIT Procedure**

The indications for the EXIT procedure have been organized into 4 broad categories (Table)\(^10\):

1. EXIT to airway
2. EXIT to extracorporeal membrane oxygenation (ECMO)
3. EXIT to resection
4. EXIT to separation

**EXIT to airway.** Airway-specific indications can be further classified as extrinsic (arising from a congenital anatomic deformation of the head and/or neck), intrinsic (due to abnormal laryngotracheal development), or iatrogenic.\(^10\) Cervical teratomas and lymphatic malformations are the most common
causes of significant extrinsic compression and distortion of the cervical and tracheoesophageal structures at birth; less common causes include severe micrognathia, giant ranula, and fetal epignathus. Congenital high airway obstruction syndrome (CHAOS) encompasses a spectrum of rare anomalies including laryngeal web, laryngeal atresia, laryngeal cyst, and tracheal atresia or stenosis, each associated with near-complete to complete intrinsic fetal airway obstruction. Iatrogenic etiologies refer to tracheal clipping or balloon occlusion in CDH.

EXIT to ECMO. The EXIT procedure to ECMO, although rare, is typically indicated for fetuses diagnosed with severe congenital heart disease (eg, severe aortic stenosis, hypoplastic left heart syndrome with restrictive atrial septum) and/or severe CDH. In cases of high risk for fetal hypoxia and acidosis, ECMO support is prepared in the operating room to be initiated after securing the airway and before umbilical cord clamping in order to avoid hemodynamic instability and rapid decompensation during neonatal resuscitation.

EXIT to resection. Indications for EXIT to resection include thoracic or mediastinal masses, congenital cystic adenomatoid malformations, and bronchopulmonary sequestration. ECMO is often prepared on standby for such cases due to the risk for fetal cardiovascular collapse once the mass has been removed.

EXIT to separation. The EXIT procedure to separation has been described for the management of conjoined twins.

In addition to the above, planned interventions during the EXIT procedure include establishment of vascular access and administration of resuscitative medications, such as surfactants in preterm deliveries.

Prenatal Diagnosis and Preoperative Planning

Appropriate preparation for the EXIT procedure begins with prenatal diagnosis. Advancements made over the last 2 decades in prenatal diagnostic imaging have significantly improved the detection and management of many congenital malformations previously determined untreatable or fatal. Typically the malformations are first detected on routine ultrasonography; high-resolution fetal ultrasonography aids in determining the extent of the disease process, as well as ruling out possible causes.
associated anomalies or findings, such as polyhydramnios.\textsuperscript{5,13} Ultrasonic evaluation also may include fetal echocardiography. Depending on the diagnosis, fetal karyotype or maternal triple screen analysis may be conducted to rule out major genetic abnormalities.\textsuperscript{2} The gold standard is ultrafast fetal magnetic resonance imaging, with sensitivity in etiology prediction greater than 90%.\textsuperscript{3,5,10}

The preoperative planning process begins once a potential candidate for the EXIT procedure has been identified, usually within the weeks after routine 20-week gestation ultra-sonography. Consideration must be given not only to the severity of the anomaly diagnosed but also to other possible concomitant, potentially lethal, anomalies or syndromes.\textsuperscript{5,10} The decision-making process should acknowledge the existence of 2 patients in extrapolation of the risks versus benefits for the EXIT procedure, particularly in instances in which other complicating abnormalities are known to occur.\textsuperscript{5} Although there are no absolute maternal contraindications to the EXIT procedure, the evaluation of each case must weigh coexisting disease or comorbidity (eg, preeclampsia, morbid obesity, abnormal uterine anatomy) that significantly increases the maternal surgical and anesthetic risks.\textsuperscript{15} Specific medical needs of the mother during the immediate postpartum period also should be addressed when the EXIT procedure is performed in institutions devoted mainly to the pediatric population. In instances of multiple fetal pregnancies, special consideration must be made for the benefits of the EXIT procedure on the affected fetus, while exposing the unaffected fetus to a significant level of risk.\textsuperscript{2} Due diligence must be performed in communicating to the patient and family members the risks, benefits, and alternatives to the EXIT procedure, as well as the potential long-term postoperative implications and management of the fetal condition.\textsuperscript{5}

An ethics consultation may be indicated.\textsuperscript{10} Dickens and Cook\textsuperscript{16} noted: “Background legal and ethical questions that arise once fetal surgery is shown effective for promoting children’s general long-term health interests are not whether pregnant women can give their informed consent to it, but whether they can decline.” The lawful parental obligation to obtain or consent to medical care for children after birth is established; at this time, maternal responsibilities to the fetus in utero are not “generally recognized.” Pregnant women are in most cases protected by the general human right to security of the person and bodily integrity against unwanted abdominal surgery.\textsuperscript{16}

Discussions among personnel of the EXIT procedure team also must take place. A multidisciplinary team typically includes, but is not limited to, an obstetrician, a neonatologist, maternal and fetal anesthesiologists, at least 2 pediatric surgeons, a pediatric otorhinolaryngologist, and maternal and neonatal nursing staff.\textsuperscript{2,6}

The optimal gestational age for a scheduled EXIT procedure varies according to diagnosis, with the overriding goal to avoid initiation of labor.\textsuperscript{2} Reversal of tracheal occlusion in fetuses with CDH occurs within the 31st week, on average\textsuperscript{6}; however, the timing of intervention in all indications for EXIT must be weighed against the increased morbidity associated with prematurity.\textsuperscript{10} Many EXIT to airway procedures are performed electively at late preterm or term (within the 36th-38th week of gestation).\textsuperscript{2,3} Serial ultrasound surveillance of the airway obstruction should be conducted in the preoperative period. Amnioreduction may be indicated before or during surgery, as polyhydramnios may obscure intraoperative placental mapping or increase the risk for placental separation and cord prolapse.\textsuperscript{3,5}

The operating room setup for the EXIT procedure necessitates a 2-room layout (ideally in immediate proximity): one for the maternal surgical setup, and the second for neonatal intervention and/or resuscitation. Organization of the EXIT procedure room must accommodate not only the
number of personnel involved but also the requirement each team member has for simultaneous access to the maternal abdomen (Figure 1).  

**Anesthetic Considerations and Management**

Although the following discussion emphasizes the differences in anesthetic goals for the EXIT procedure versus those for cesarean delivery, many of the precautions taken in caring for a patient in the third trimester of pregnancy remain the same. The maternal physical examination includes a complete assessment of the patient’s airway and determination of suitability for rapid sequence induction. Prophylaxis for aspiration risk is indicated. The patient is positioned supine with left uterine displacement to avoid aortocaval compression and maximize uterine blood flow to the placenta. A lateral tilt of 30 degrees has been found to result in inferior vena cava volumes significantly greater than those in the supine position in pregnant patients. The maternal laparotomy incision is made in standard Pfannenstiel fashion followed by low transverse hysterotomy when possible, permitting the option of vaginal delivery for future pregnancy. Unlike cesarean delivery, ultrasonography is used to map the placental and fetal positions before incision; an anterior placenta dictates a laparotomy incision that may be larger or classical with posterior or fundal hysterotomy.

**Anesthetic Choice**

The quintessential difference in anesthetic management for the EXIT procedure is the level of uterine relaxation required to maintain adequate placental circulation for the duration of the operation preceding delivery. Whereas the major anesthetic goal of cesarean delivery under general anesthesia is to reduce the risk for neonatal depression and maternal hemorrhage by minimizing exposure to the inhalational agent, optimal relaxation of the uterus for the EXIT procedure is commonly provided by high-dose inhalational anesthesia. Desflurane (Suprane, Novaplus/Baxter Healthcare), with its high potency in uterine relaxation, yet also with its low blood:gas partition coefficient resulting in rapid recovery of uterine tone, is a popular choice. Isoflurane and sevoflurane also have been successfully used, while nitrous oxide is commonly avoided to allow delivery of high inspired oxygen concentrations to the fetus. Reports of inhalational agents combined with neuraxial techniques (lumbar epidural, combined spinal-epidural) and with supplemental IV anesthesia have been described as alternatives to the high-dose inhalational anesthetic technique. Intraoperative neuraxial techniques that solely rely on IV nitroglycerin for uterine relaxation have been linked to greater maternal morbidity, including hypotension, reflex tachycardia, methemoglobinemia, tachyphylaxis, headache, and pulmonary edema. Combined propofol and remifentanil (Ultiva, Mylan) infusions have been found in in vitro studies to demonstrate a dose-dependent reduction in isolated gravid uterine muscle contractility.  

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![Figure 1. Operating room (OR) layout.](image)
In a retrospective clinical study by Boat et al,\textsuperscript{20} adequate uterine relaxation (assessed by a surgeon on palpation and visual inspection of the uterus) comparable to that under desflurane 2.5 minimum alveolar concentration (MAC) was achieved using desflurane 1.5 MAC with a propofol and remifentanil infusion. The reduced dose and exposure time to maternal desflurane were found to decrease the incidence of moderate to severe left ventricular dysfunction, suggesting less fetal cardiac depression.\textsuperscript{20} Propofol and remifentanil infusions also have been documented in EXIT procedures for patients at risk for malignant hyperthermia.\textsuperscript{4} The universal goal is to establish maximal uterine relaxation before hysterotomy, to maintain uterine relaxation throughout the EXIT procedure, and to recover uterine tone immediately upon clamping of the umbilical cord, while maintaining normal hemodynamic stability.

**Monitoring**

*Maternal monitoring.* Maternal hemodynamic stability is critical to the preservation of adequate uteroplacental circulation required for the EXIT procedure. Although mild, transient decreases in maternal oxygenation or blood pressure may be tolerated by the fetus, any disruption in ventilation, perfusion, or acid–base status of the mother is a potential threat to fetal well-being.\textsuperscript{15} Therefore, in addition to routine monitors for cesarean delivery (pulse oximetry, end-tidal carbon dioxide, peripheral nerve stimulation, continuous electrocardiography, urinary catheter, and core temperature sensor), a radial arterial line is placed.\textsuperscript{3}

*Fetal monitoring.* Fetal monitors include a specially adapted reflectance pulse oximeter (placed on the fetal hand after externalization) and, if available, continuous fetal echocardiography. By enabling direct visualization of fetal heart rate, intraventricular volume, myocardial contractility, atrioventricular valve competency, and ductal constriction, continuous echocardiography has been reported to detect the earliest signs of fetal hemodynamic instability, providing vital moments for diagnosis and intervention before fetal compromise occurs.\textsuperscript{2} Poor fetal oxygenation (<40%) or a decrease in heart rate (>20% of baseline, or <140 beats per minute) is often the result of poor placental perfusion or umbilical cord compression, and must be promptly assessed.\textsuperscript{4,13} Ultrasound examination of umbilical cord blood flow as well as periodic fetal hemoglobin and blood gases from the umbilical artery and vein also have been used.\textsuperscript{6}

**Uteroplacental Circulation**

In addition to close maternal hemodynamic and fetal monitoring, appropriate maintenance of uteroplacental perfusion requires a delicate balance of uterine relaxation, IV vasopressor support, and IV fluids.\textsuperscript{5} While the American Society of Anesthesiologists Task Force on Obstetric Anesthesia\textsuperscript{21} states that direct α-agonist “phenylephrine may be preferable because of improved fetal acid-base status,” phenylephrine and ephedrine have been used during fetal surgery to maintain maternal arterial pressures.\textsuperscript{4} Regardless of the agent chosen, hypotension must be promptly treated.\textsuperscript{15} Vasopressors are favored over volume expansion when the risk for maternal pulmonary edema is increased.\textsuperscript{5}

The timing and efficacy of uterine relaxation required before hysterotomy necessitate close communication between the surgical and anesthesia teams.\textsuperscript{2,10} In addition to the anesthetic agents, indomethacin (50 mg intrarectally, usually on the morning of surgery or after induction) can be administered for tocolysis.\textsuperscript{2} Nitroglycerin IV bolus (20-100 mcg) and infusion (0.5-1 mcg/kg/minute) also have been described, both as a supplemental agent when volatile anesthesia cannot attain optimal uterine tone\textsuperscript{15} or when total IV anesthesia is used.\textsuperscript{4} The easily titratable, short-acting effects of
nitroglycerin are preferred over magnesium use.\textsuperscript{2} Terbutaline administration also has been documented.\textsuperscript{6} Equally important to placental perfusion is maintenance of uterine volume. Continuous amniinfusion of lactated Ringer’s solution warmed via a rapid infusion device preserves utero-placental circulation by preventing uterine contraction, placental detachment, and umbilical cord vessel spasm.\textsuperscript{5,6} Maternal infusion of warmed IV fluids is indicated to avoid heat loss.\textsuperscript{6}

**Fetal Anesthetic Considerations**

In addition to maternal transfer of anesthetic agents across the placenta, anesthesia and analgesia may be delivered directly to the fetus by IV or intramuscular injection.\textsuperscript{4,6} A cocktail of fentanyl, neuromuscular blockade, and atropine may be administered to the fetus by the surgeon before hysterotomy under ultrasound guidance or immediately after exposure of the fetal head and shoulders.\textsuperscript{2,4,6} Such measures are indicated for the EXIT procedure in part to ensure inhibition of fetal movement during surgical intervention. Fetal anesthesia also serves to preserve uteroplacental circulation, as fetal attempts to breathe can precipitate placental detachment.\textsuperscript{2} Evidence for the development of the nociceptive pathway by midgestation and the intact pain response in the late-term fetus also support intraoperative fetal analgesia.\textsuperscript{4,10} Investigation of the fetal stress response during surgical stimulation at term has found that increased hormonal and catecholamine activity link to poor fetal outcomes, including adverse effects on long-term neurodevelopment and behavior responses to pain.\textsuperscript{2,15} The fetal stress response is ablated with the administration of anesthesia.\textsuperscript{22}

Although the fetal airway is typically secured by a surgeon, specifically a pediatric otorhinolaryngologist, the EXIT airway management algorithm presented in 2015 by Walz and Schroeder\textsuperscript{10} (Figure 2) provides helpful insight into the discussion of this case. The stepwise approach differentiates first, intrinsic versus extrinsic obstruction, and progresses through increasingly invasive options to secure the airway. The recommended sequence of maneuvers for intrinsic airway obstruction, namely CHAOS, is confirmation of the prenatal diagnosis with laryngoscopy and/or bronchoscopy followed by establishment of a secure airway with tracheostomy. For extrinsic airway obstruction, endotracheal intubation is attempted first by direct laryngoscopy, followed by rigid bronchoscopy, then tracheotomy with retrograde intubation, and finally tracheostomy. Securing the fetal airway by tracheostomy is often complicated further by distortion of airway anatomy by the neck mass. The severe fetal head extension associated with large neck masses can pull the carina from the chest toward the neck during fetal development, resulting in pulmonary hypoplasia.\textsuperscript{2,3} Such anomalies in fetal development also lead to a tenuous postoperative course. Adjunctive equipment and procedures (eg, armored endotracheal tubes, ultrasound guidance, and surgical manipulation or resection of the mass) are encouraged where clinically appropriate. A case requiring total mass excision was performed completely on uteroplacental bypass, lasting over 150 minutes!\textsuperscript{16} Adherence to the EXIT airway management algorithm requires a complete arsenal of sterile airway equipment, including rigid infant-size laryngoscope handles, size 1 and 2 straight Miller blades, size 2.5 and 3.0 rigid ventilating bronoscopes, wire-reinforced cuffless endotracheal tubes, tracheostomy tubes, neonatal surgical tracheostomy instruments, and a Mapleson circuit for manual ventilation.\textsuperscript{3} Once the airway is established and confirmed patent by flexible endoscopy, the EXIT to airway procedure is complete. Surfactant can be administered via a 4-Fr feeding tube through the endotracheal tube or bronchoscope if indicated by preterm gestational age, and ventilation initiated.\textsuperscript{5,11,13} The umbilical cord is clamped and cut, the placenta delivered, and care of the neonate transferred to the neonatologist for further monitoring, with surgery pending—sometimes immediately; ideally the surgical intervention should be delayed until the neonate is further optimized.\textsuperscript{10}
EXIT Procedure Completion

Communication between the surgical and anesthesia teams is critical to the timing in reversal of uterine relaxation. High-dose inhalational anesthetic agents are reduced after clamping of the umbilical cord and sometimes transitioned to IV anesthetic agents. If a lumbar epidural is placed before induction for postoperative pain control, administration of local anesthetic and/or opioid is typically delayed until after delivery to avoid intraoperative maternal hypotension. Oxytocin administered as a slow bolus or by continuous infusion titrated to uterine response has been reported as the single uterotonic agent required, although methergine and carboprost (Hemabate, Pfizer) supplementation also may be indicated.2,6 Because increased risk for uterine dehiscence is a reported complication of the EXIT procedure, precautions against coughing or straining during emergence are recommended to prevent disruption of uterine closure.15

Complications

The EXIT procedure presents an increased risk for maternal hemorrhage, particularly for procedures of prolonged duration, due to the requirement for reduced uterine tone by an enhanced depth of general anesthesia, and possibly a vertical uterine incision.3,15 Although early data confirmed greater maternal blood loss in EXIT versus cesarean deliveries, recent reports have demonstrated no significant difference between the 2 procedures regarding the change in hematocrit level or transfusion requirements.2,10 Although patients for EXIT procedures have been identified as having more complications in wound healing, they do not differ from cesarean delivery patients in hospital length of stay.6 With respect to long-term fertility, women who have attempted repeat pregnancies after EXIT procedures have had successful live births, although patients are counseled that labor should be
avoided if a classical incision was made due to the increased risk for uterine dehiscence.\textsuperscript{3,6} No maternal deaths have been reported for the EXIT procedure.\textsuperscript{10}

Reported intraoperative fetal complications include premature loss of placental support, emphasizing the critical role of continuous fetal monitoring, and technical difficulties involved in securing an anticipated obstructed airway.\textsuperscript{10} A noted complication of tracheal clip removal during the EXIT procedure for CDH is tracheal tear; this complication and others related to neck dissection for tracheal clips have been avoided by occlusion with the insertion of an intratracheal balloon.\textsuperscript{6} Complications of the postnatal clinical course are specific to the indicating diagnosis (eg, the morbidity and mortality related to neonatal cervical teratoma is dictated primarily by the degree of pulmonary hypoplasia, as most deaths are the result of respiratory failure).\textsuperscript{10}

**Management of the Case Presented**

Serial amnioreductions were performed at 33, 34, and 35 weeks' gestation; the patient’s pregnancy continued otherwise uneventfully to the scheduled EXIT procedure date. A lumbar epidural catheter was placed preoperatively, and a 3-mL test dose (lidocaine 45 mg and epinephrine 15 mcg) was administered before arriving in the operating room where routine monitors were initiated. The patient was positioned at 30 degrees left-lateral tilt and a rapid sequence induction (propofol 2 mg/kg, succinylcholine 1.5 mg/kg) was performed. Large-bore peripheral venous access and radial invasive arterial blood pressure lines were established. Maternal blood pressure goals of systolic blood pressure greater than 100 mm Hg and mean arterial pressure within 10% to 20% baseline were maintained via titration of continuous phenylephrine infusion (15-50 mcg/minute) and phenylephrine (100-200 mcg) and ephedrine (5-10 mcg) bolus doses as needed. Maternal paralysis was maintained with vecuronium boluses (0.01 mg/kg) and monitored by train-of-four ulnar nerve stimulation. The placental position and borders were delineated via sterile ultrasonography before lower transverse abdominal skin incision. The desflurane dose was increased from 0.5 MAC to between 2 and 3 MAC and optimal uterine relaxation confirmed upon surgical palpation of the uterus before the lower uterine hysterotomy was performed with a hemostatic stapling device.

The fetal head, neck, upper torso, and right upper extremity were extracted, and the fetal pulse oximeter was secured to the right hand. Intrauterine volume was maintained by amniinfusion of warmed lactated Ringer’s solution via a rapid infusion device. Fetal peripheral IV access was established, and fetal fentanyl (10 mcg/kg), atropine (20 mcg/kg), and vecuronium (0.2 mg/kg) were administered intramuscularly by the surgeon. During percutaneous macrocyst decompression, fetal heart rate and oxygen saturation were monitored via fetal pulse oximetry and continuous fetal echocardiography by the pediatric cardiologist. The fraction of inspired oxygen was titrated to maintain fetal oxygen saturation between 50% and 70%. Endotracheal intubation (2.5 mm inner diameter) was achieved on the second attempt via rigid bronchoscopy after direct laryngoscopy was unsuccessful. After confirmation of endotracheal tube insertion and improving fetal oxygenation via adequate bag-valve ventilation, the endotracheal tube was sutured into place and the umbilical cord clamped and cut. The fetus was delivered and transferred by the neonatologist to a second prepared operating room for further evaluation and treatment. Immediately after delivery of the placenta, an oxytocin infusion (40 U in 1,000 mL) was started and the inhalational anesthetic dose reduced to 0.5 MAC as the surgical team confirmed improved uterine tone. With hemostasis established, bolus doses of local anesthetic (0.1% ropivacaine 3 mL every 5 minutes to 15 mL total volume) were administered via the epidural catheter for postoperative pain control. After the return of 4 muscle twitches, the neuromuscular block was fully reversed and the patient’s trachea extubated. The patient was
transferred from the operating room to the post-anesthesia care unit in stable condition.

Conclusion

The EXIT procedure offers a unique opportunity to provide a hemodynamically stable environment for intervention of a potentially life-threatening fetal condition. This process requires early and advanced prenatal diagnosis along with preoperative preparation of the patient, patient’s family, and personnel of the highly specialized, multidisciplinary surgical, anesthesia, obstetric, neonatology, and nursing team. Specific to the anesthesiologist are responsibilities of maternal hemodynamic stability and uterine relaxation to maintain adequate uteroplacental circulation, maternal ventilation, and postoperative pain control, as well as fetal well-being when immediate resuscitation or surgical intervention is indicated. These goals have been met using a broad spectrum of anesthesia techniques that will set the foundation for future applications of the EXIT procedure.

Dr. Elizabeth A.M. Frost, who is the editor of this continuing medical education series, is clinical professor of anesthesiology at The Mount Sinai School of Medicine in New York City. She is the author of Clinical Anesthesia in Neurosurgery (Butterworth-Heinemann, Boston) and numerous articles. Dr. Frost is past president of the Anesthesia History Association and former editor of the journal of the New York State Society of Anesthesiologists, Sphere. She is also editor of the book series based on this CME program, Preanesthetic Assessment, Volumes 1 through 3 (Birkhäuser, Boston) and 4 through 6 (McMahon Publishing, New York City).
ABBREVIATED REFERENCES

Post-test

1. One of the most common interventions performed during the EXIT procedure is:
   a. fetal mediastinal mass resection
   b. securing of the fetal airway
   c. tracheal occlusion in fetuses with severe CDH
   d. ECMO cannulation

2. Which of the following is *not* an indication for the EXIT procedure?
   a. EXIT to resection
   b. EXIT to separation
   c. EXIT to airway
   d. EXIT to destination

3. The gold standard for prenatal diagnosis of airway obstruction is:
   a. ultrafast fetal magnetic resonance imaging
   b. high-resolution fetal ultrasound
   c. fetal karyotype analysis
   d. maternal triple screen analysis

4. Which member of the multidisciplinary team is usually consulted for securing the fetal airway?
   a. Obstetric anesthesiologist
   b. Pediatric anesthesiologist
   c. Pediatric otorhinolaryngologist
   d. Neonatologist

5. Uterine relaxation is maximized at what point during the EXIT procedure?
   a. Before skin incision
   b. Before hysterotomy
   c. After hysterotomy
   d. After exteriorization of the fetal head and neck
6. Which fetal monitor provides the earliest detection of fetal compromise?
   a. Fetal pulse oximetry
   b. Fetal electrocardiography
   c. Umbilical artery Doppler
   d. Fetal echocardiography

7. Which of the following benefit(s) are reported after fetal anesthesia?
   a. Inhibition of fetal movement during surgical intervention
   b. Preserved uteroplacental circulation
   c. Improved neonatal pain scores
   d. Inhibition of fetal movement during surgical intervention and preserved uteroplacental circulation

8. Uterine relaxation is reversed at what point during the EXIT procedure?
   a. After hysterotomy
   b. After exteriorization of the fetal head and neck
   c. After clamping of the umbilical cord
   d. After uterine closure

9. Which maternal complication is reported more commonly after the EXIT procedure than after cesarean delivery?
   a. Need for transfusion
   b. Increased hospital length of stay
   c. Complications in wound healing
   d. Infertility

10. Which anomaly is associated with increased morbidity and mortality after the EXIT procedure for neonatal cervical teratoma?
    a. Severe pulmonary hypoplasia
    b. Imperforate anus
    c. Intratumoral hemorrhage
    d. Teratoma size greater than 5 cm