



# Standard Operating Procedures Ex Utero Intrapartum Therapy (EXIT)

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## Abstract

EXIT, or Ex Utero Intrapartum Treatment, is a sophisticated technique designed to ensure a safe and effective transition for a fetus from the womb to the outside world while maintaining essential placental support. The applications of the EXIT approach are continually expanding and encompass various scenarios like facilitating airway access, conducting surgical resections, implementing extracorporeal membrane oxygenation (ECMO), and aiding in the separation of conjoined twins.

The method involves carefully planned delivery of fetus through hysterotomy, all the while keeping the uterus relaxed and ensuring placental assistance. This approach allows for the gradual establishment of neonatal cardiopulmonary stability in a controlled manner. The range of fetal interventions during the EXIT procedure is diverse, including tasks such as endotracheal intubation, tracheostomy, mass excision, removal of temporary tracheal devices, and ECMO.

A pivotal factor in the success of an EXIT procedure is the formation of a highly skilled and collaborative multidisciplinary team. This team, equipped with broad expertise in fetal intervention, works seamlessly across the stages of pre-, intra-, and postpartum care, ensuring the best possible outcomes for the mother and the newborn.

## Keywords

- CHAOS
- ECMO
- ex utero intrapartum
- placental circulation
- tracheal balloon

## Introduction

EXIT, or Ex Utero Intrapartum Treatment, is a sophisticated technique designed to ensure a safe and effective transition for a fetus from the womb to the outside world while maintaining essential placental support. The applications of the EXIT approach are continually expanding and encompass various scenarios like facilitating airway access, conducting surgical resections, implementing extracorporeal membrane oxygenation (ECMO), and aiding in the separation of conjoined twins.

## EXIT Indications<sup>1</sup>

1. EXIT-to-Airway: congenital high airway obstruction, severe micrognathia, obstructing mass, tracheal balloon
2. EXIT-to-Resection: head, neck, thoracic, or mediastinal mass
3. EXIT-to-ECMO: cardiothoracic anomaly or severe congenital diaphragmatic hernia
4. EXIT-to-Separation: conjoined twins

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## Consent

Detailed consent should be obtained from the parents, explaining the risks involved to the mother and fetus. The *risks for mother* include:

1. Risk of general anesthesia
2. Intrapartum and postpartum hemorrhage (PPH)
3. Extension of the incision line
4. Need for massive blood transfusion
5. Need for intensive care unit (ICU) care
6. Peripartum or postpartum hysterectomy
7. Pulmonary edema
8. Sepsis
9. Disseminated intravascular coagulation
10. Shock

## Risk for Fetus

1. Hypotension
2. Hypoxia
3. Perinatal death if the airway cannot be secured
4. Fetal brain damage
5. Need for further definitive surgeries

## Perioperative Considerations for EXIT

### Prenatal Evaluation

1. Referral to a tertiary care center with an expert team
2. Accurate prenatal diagnosis/precise diagnostic imaging and evaluation by the EXIT team is important for proper planning and management and avoiding delays during the procedure
3. Complete prenatal workup as necessary: for example, genetic testing, amniocentesis, fetal echocardiography, magnetic resonance imaging, etc.
4. Formation of an experienced multidisciplinary EXIT team and operative planning
5. In-depth multidisciplinary prenatal education and counseling for the couple

## The EXIT Team

- Preoperative evaluation by:
  1. Maternal-fetal medicine expert
  2. Pediatric surgeons
  3. Anesthesiologists
  4. Radiologists
  5. Fetal cardiologists
  6. Neonatologists
  7. Social workers
- Intraoperative team:
  1. Maternal anesthesiologist
  2. Fetal anesthesiologist
  3. Scrub nurses, 2
  4. Circulating nurses, 2
  5. Airway cart nurse
  6. Maternal-fetal medicine specialists
  7. Fetal cardiologist for intraoperative echocardiography—as per case

8. Pediatric surgeons
9. Ear, nose, and throat team
10. Obstetrician
11. ECMO team—as per case

- Neonatal team:
  1. Neonatologist
  2. Surgical advanced practice nurses
  3. Neonatal nurses
  4. The second operating room (OR) team is on standby in the adjacent operation theater (OT)

## Essential Elements of the EXIT Procedure<sup>2</sup>

- Uterine relaxation
  1. Inhalational agents
  2. Tocolytic agents
- Maintenance of uterine volume
  1. Amnioinfusion
  2. Partial delivery
- Fetal
  1. Anesthetic
  2. Blood product availability
  3. Echocardiography
  4. Intravenous access
  5. Pulse oximetry
- Maternal
  1. Arterial line
  2. Blood product availability
  3. Electrocardiogram
  4. End-tidal CO<sub>2</sub>
  5. Pulse oximetry

## Maternal OT Setup

### Maternal Instrument Table

1. Cesarean delivery instrument set and drapes
2. Cord clamp
3. Surgeon-specific sutures, gloves, and supplies
4. Have an abdominal hysterectomy set available

### Respiratory Instrument Table

1. 1.5-mm, 0-degree, rigid, neonatal bronchoscope
2. 2.7-mm, 0-degree, rigid, neonatal bronchoscope
3. 2.2-mm, 0-degree, flexible neonatal bronchoscope, with facility for video bronchoscopy
4. Bronchial suction tips
5. Single and double light cords
6. Pediatric laryngoscope handles
7. Size 0 Miller and Wisconsin laryngoscope blades
8. Endotracheal tubes uncuffed sizes 2.0, 2.5, 3.0, and 3.5
9. Pediatric stylet
10. Pediatric Magill forceps
11. Pediatric masks and bags
12. Pediatric bag-valve mask oxygen tubing
13. Laryngeal mask airways sizes 1.0, 1.5, and 2.0

14. Pediatric tracheostomy tray
15. Tracheostomy tubes uncuffed sizes 2.5, 3.0, and 3.5
16. Suction catheters
17. Pulse oximetry probes
18. Neonatal electrocardiogram electrodes

### Preop Checklist

1. Surgical consent
2. Review patient's medical history, physical examination, and imaging
3. Presence of allergies
4. Review of the patient's baseline vital signs
5. Confirm the patient's identity
6. Planned surgical procedure
7. Preop medications

### Preparation

1. At some date prior to proceeding with an EXIT procedure, the multidisciplinary team should assemble to rehearse the steps of the procedure and the specific roles each individual team member will perform.
2. There are essentially two patients in the OR at the same time—the mother and fetus/neonate. There should be two separate teams that are each responsible for one patient, including separate surgeons, anesthesiologists, and scrub nurses.
3. All required instruments and equipment should be discussed beforehand and made readily available for both patients.
4. Any possible complications should be openly recognized and troubleshoot, including maternal cardiopulmonary instability, massive uterine hemorrhage, and inability to establish a neonatal airway despite maximal efforts.
5. Due to the increased risk of maternal blood loss over standard cesarean section, blood should be on hand in the event transfusion is indicated.

### Operating Room Requirements

1. Placement on the OT table includes supine positioning with a leftward tilt to prevent compression of the inferior vena cava.
2. Adequate intravenous access is established and sequential compression devices are placed.
3. A preoperative ultrasound is performed to define the placenta and assess the position of the fetus. This helps with the decision of hysterotomy location to avoid bleeding or other complications.
4. Maternal, deep general anesthesia is then established, ensuring adequate doses of inhalation anesthetics to maintain uterine relaxation throughout the procedure, avoiding maternal hypotension. Indirect fetal anesthesia is achieved.
5. Adjunctive myometrial tocolytics that have been used include indomethacin, terbutaline, and nitroglycerine.
6. Invasive maternal blood pressure monitoring is performed due to the risk of hypotension in the setting of

high-dose anesthetics, impaired venous return, and the potential for large-volume hemorrhage.

7. It is essential to maintain adequate maternal blood pressure to provide appropriate uteroplacental circulation and subsequent fetal perfusion during the procedure.
8. Other considerations prior to proceeding with the operation include placement of a urinary catheter and epidural catheter for postoperative maternal pain management.

### Procedure Steps<sup>3–8</sup>

1. If there is polyhydramnios, amniotic fluid is drained, before incision to reduce maximum vertical pocket to 6 to 8 cm.
2. A laparotomy is made, generally via a Pfannenstiel, Maylard, or low midline incision depending on the anticipated hysterotomy location.
3. A hysterotomy is made away from the placenta generally in the less-muscular lower uterine segment to reduce blood loss. In the case of placenta previa or anterior placenta, the incision may be in an upper segment or fundal. Special hysterotomy staplers may be used to avoid blood loss.
4. If a large head or neck mass is present, the hysterotomy may need to be extended quite far to allow adequate exposure.
5. The fetus is then partially delivered, including the head, neck, and upper torso, but keeping the lower body within the amniotic cavity to maintain uterine volume and prevent rapid temperature loss. Sometimes it may be necessary to deliver the whole baby for better access, in which case the cord and baby are covered with a warm towel. The image (→Fig. 1) shows a fetus with a large teratoma in the neck, laryngoscopy being attempted after delivery of head and neck.
6. The maintenance of uterine volume is important for preventing premature uterine contraction and delivery of the placenta, which would abort the procedure. A continuous infusion of warm lactated ringer solution is instilled into the uterine cavity to prevent intraoperative fluid loss.



**Fig. 1** Laryngoscopy being attempted after delivery head and neck before delivery of the baby.

7. Fetal hemodynamic monitoring is established and medications are administered to provide analgesia and paralysis via either the intramuscular or intravenous route (usually transplacental anesthesia works).
8. At the same time, the team can proceed with the fetal/neonatal intervention that was planned.
9. If the indication for the procedure was to establish a neonatal airway, this process generally proceeds in a stepwise fashion starting with attempts at endotracheal intubation via direct laryngoscopy, then proceeding to bronchoscopy, and progressing to tracheostomy.
10. Once the neonatal airway is established, hand-bagging is initiated and the neonatal pulse oximeter is closely monitored. At this point, the umbilical cord can be clamped, and this portion of the operation requires communication and coordination between the surgeon and anesthesiologist.
11. Immediately following cord clamping, the inhalational anesthetics and tocolytics are discontinued and uterotonics are administered to the mother to stimulate uterine contraction and prevent uncontrolled hemorrhage.
12. The neonate is resuscitated as necessary by the waiting neonatal intensivist team and then is transported either to the neonatal ICU or to an adjacent OR if further intervention is warranted.
13. Maternal hemostasis becomes the focus at this point, as uterine atony may be prolonged following the recent administration of myometrial relaxing medications. Maneuvers that can assist with uterine contraction and hemostasis include uterine massage, administration of uterotonics, and placement of B-Lynch sutures.
14. Once hemostasis is achieved, the hysterotomy and laparotomy are closed and the mother is awakened from anesthesia. Her postoperative disposition is dependent on her clinical status during the case and ICU versus general ward placement should be discussed between the surgeon and anesthesiology teams.

### Postoperative Considerations

1. Mothers recovering from an EXIT procedure differ from those who undergo standard cesarean deliveries.
2. Parents cannot immediately interact with or even view their neonates after delivery. Because many of these neonates undergo immediate surgical intervention, the parents' first glimpse of the child will be of an intubated, sedated child with monitors, invasive catheters, and distorted swollen facies.
3. Continued emotional support, social services, and education will help ease this transition.

### Patient Information Leaflet

- What is the EXIT procedure?  
An EXIT procedure is the surgical delivery of your baby through incisions in your abdominal wall and uterus. Doctors will help your baby to breathe before the baby is completely delivered. To do this, the doctors may have to put a breathing tube in your baby's throat and lungs. Depending on the situation, the doctors may need to perform surgery to help your baby breathe.
- What are the risk factors for undergoing the procedure? Only you and your doctor can decide whether the benefits outweigh the risks. Some possible risks for both you and your baby include:
  - For you:
    1. Risk of general anesthesia
    2. Risk of significant blood loss (PPH), requirement for blood transfusion
    3. Risk of incision extension
    4. Risk of postoperative infection
    5. Risk of uterine rupture in future pregnancies
  - Fetal risks:
    1. Hypotension
    2. Hypoxia
    3. Hypothermia
    4. Bradycardia
    5. Nerve palsies
    6. Fetal/neonatal demise
- Where will the surgery be done?  
The surgery may be performed in a hospital that specializes in the care of pregnant mothers. A team of health care providers will be there to do your surgery and a separate team will work with your baby.
- What is the postoperative care of the mother after the procedure?  
While you are recovering from surgery
  1. Your recovery time might be longer than usual cesarean sections
  2. You might not be able to see your baby till the time baby is stable
- What is the postoperative care of the baby after the EXIT procedure?  
Your baby will need normal newborn baby care but he or she may also need special care in a neonatal (baby) ICU. This will depend on the procedure performed on your baby. It is best to ask your doctor specifically.
- What happens after we go home?  
Your baby may need additional procedures depending on his or her health. Discuss these procedures with your baby's doctor.
- Call your doctor immediately if you experience any of the following postoperative complications:
  1. Excessive vaginal bleeding;
  2. Swelling or excessive bleeding from the surgical site;
  3. Passing large (i.e., plum-sized) blood clots;
  4. Painful and/or swollen and red calves; or
  5. Foul-smelling vaginal discharge.
- Call your baby's doctor immediately if your baby experiences any of the following postoperative complications:
  1. Difficulty swallowing or breathing or
  2. Visible swelling of the cyst.

- Other postoperative complications depend on the procedure performed. Your baby's doctor will tell you about other possible complications.

#### Conflict of Interest

None declared.

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