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# The application of ex utero intrapartum treatment (EXIT) procedure for cardiothoracic disorders

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## ABSTRACT

The ex utero intrapartum treatment (EXIT) procedure was primarily developed to reverse temporary tracheal occlusion in patients with fetal surgery for congenital diaphragmatic hernia. Nowadays, it is widely used to resect fetal neck masses and to maintain an unobstructed airway. It is indicated for the management of several cardiothoracic diseases, including mediastinal or lung mass resection, drainage of pleural effusions, palliative treatment of critical congenital heart disease and establishment of EXIT-to-extracorporeal membrane oxygenation (ECMO). EXIT has been attempted successfully in many centers, and it has been proven that mothers and babies tolerate the procedure well. Maternal and fetal surveillance during anesthesia is important to maintain maternal blood pressure and placental blood flow and fetal oxygenation. The aim of this article is to discuss the application of the EXIT procedure for the management of fetal cardiothoracic diseases.

*Key words: anesthesia, fetus, mediastinal neoplasms, pleural effusion*

## INTRODUCTION

The ex utero intrapartum treatment (EXIT) procedure was primarily developed to reverse temporary tracheal occlusion in patients undergoing fetal surgery for congenital diaphragmatic hernia. (1) The EXIT procedure requires an experienced multi-disciplinary team that may include pediatric surgeons, an obstetrician, neonatologist, anesthesiologist and scrub nurses. The anesthesiologist is crucial for maintaining uteroplacental perfusion and maternal arterial pressure and muscle relaxation. Fetal analgesia and paralysis are ensured with vecuronium, fentanyl and atropine before hysterectomy or immediately after fetal exposure. Cooperation between pediatric surgeons and anesthetists is anticipated for preventing uterine atony and excessive maternal bleeding. (2)

The EXIT procedure allows therapeutic interventions on the neonate while maintaining fetoplacental circulation and thereby maintaining oxygenation. The EXIT procedure was primarily established as a safe technique initially designed for reversal of tracheal obstruction in a fetus with severe congenital diaphragmatic hernia. Nowadays, it is widely used to resect fetal neck masses and to maintain an unobstructed airway. (3) Liechty et al. (3) reported that the mean duration of EXIT was 28 ± 22 minutes during intrapartum airway management for giant fetal neck masses. At present, the EXIT procedure has been extended to fetal anomalies where resuscitation may be compromised, including large thoracic masses, severe congenital diaphragmatic hernia, or pulmonary agenesis. (4) The use of the EXIT procedure in fetuses for cardiothoracic diseases has not been fully elaborated. This article will discuss the application of the EXIT procedure in fetal cardiothoracic diseases.

## MEDIASTINAL TUMORS

Fetal mediastinal teratomas can cause intrathoracic compression and non-immune hydrops fetalis, and neonatal respiratory distress. Mediastinal teratomas are usually detected on routine ultrasound during 2nd and 3rd trimester. In 2005, Merchant et al. (5) reported their experiences in managing a fetal mediastinal teratoma in 2 cases. One was successfully resected by fetal open surgery at 23-week gestation, and the other, using the EXIT procedure for establishment of an airway and tumor resection on uteroplacental support. They defined that a fetus <30-week gestation with a massive mediastinal teratoma and hydrops fetalis was an indication for open fetal surgery, while that >30-week gestation warranted an EXIT procedure. Recently, Agarwal et al. (6) reported a fetus with a large mediastinal teratoma, with large pericardial effusions and non-immune hydrops fetalis, that was successfully managed with pericardiocentesis and surgical resection of the large teratoma using the EXIT procedure. One of the cases of fetal intrapericardial teratomas that were managed by Rychik et al. (7) was by EXIT procedure at 31 weeks, and the tumor was successfully resected while on placental support.

## LUNG MASSES

The EXIT procedure is preferred for near-term fetuses with large lung masses and mediastinal compression. Cass et al. (8) reported 9 fetuses with large lung masses, causing persistent mediastinal compression that received EXIT procedures. All procedures were successful without fetal or maternal operative complications. The fetal operative time (uteroplacental bypass time) was 43.2 ± 21.8 min, and the maternal operative time was 136.1 ± 15.0 min. Comparisons between fetuses undergoing the EXIT procedure and standard delivery revealed no intergroup difference in perinatal conditions, including survival (EXIT, 100% vs. Standard delivery, 71%, p = 0.18). Bouchard et al. (2) reported a fetus with a large cystic lung lesion, evaluated at 26- and 36-week gestation, and it was noted that the mass had a constant size. The fetus

was diagnosed with congenital cystic adenomatoid malformation (CCAM), with no evidence of hydrops fetalis. An EXIT procedure was planned considering the possible difficulty of ventilation at birth. After hysterotomy, the fetal head was delivered and the baby intubated. The mass was resected on placental bypass which lasted 66 minutes. (2)

## CONGENITAL CARDIAC ANOMALIES

Some congenital cardiac anomalies become progressively severe during pregnancy . An in utero procedure can successfully prevent or minimize the progression in some cases, particularly for those fetuses evolving into hypoplastic left heart syndrome. A second choice for improving fetal outcome is the EXIT procedure, which can be performed safely by controlling the airway in fetuses with airway obstruction or intrathoracic compression due to masses. (9)

## ESOPHAGEAL ATRESIA AND STENOTIC BRONCHUS REPAIR

Bouchard et al. (2) reported a fetus diagnosed on ultrasound at 19 weeks' gestation with unilateral pulmonary agenesis, polyhydramnios and suspected esophageal atresia. An EXIT procedure was carried out on the baby for esophageal atresia repair and rib graft reconstruction of a stenotic bronchus to the solitary lung.

## EXIT-TO-ECMO

Extracorporeal membrane oxygenation (ECMO) can be used if an airway cannot be established, if the fetus and its placental support become unstable, or if the lungs cannot support the patient during the initial neonatal period. EXIT-to-ECMO facilitates airway control, arterial and venous cannula insertion for ECMO while on placental support for fetuses with severe pulmonary or cardiac malformations. Bouchard et al. (2) reported, in a fetus with a left congenital diaphragmatic hernia and a tetralogy of Fallot, EXIT-to-ECMO which was performed at 36-weeks gestation.ECMO was established by cannulating the internal carotid artery and internal jugular vein, while on uteroplacental support for 90 minutes. The EXIT procedure is also useful for fetuses separated from the uteroplacental circulation, with immediate instability of the neonate. In such cases, the EXIT procedure avoids hypoxia or acidosis during neonatal resuscitation. Marwan and Crombleholme (10) also offered EXIT-to-ECMO for fetuses with severe aortic stenosis or hypoplastic left heart syndrome associated with a restrictive atrial septum. EXIT-to-ECMO was applied with the option of traditional cardiopulmonary bypass (CPB) with an open reservoir as the baby was delivered and transferred to a separate operating room. Matte et al. (11) made use of the A Modified EXIT-To-ECMO with Optional Reservoir (METEOR) circuit to commence ECMO support with a traditional CPB by aorta-right atrium cannulation with an open reservoir and cardiotomy suction. ECMO support was initiated at 250 mL/min (100 mL/kg), the umbilical cord was clamped and the baby was fully delivered.

## PERICARDIAL EFFUSIONS

Management of isolated pericardial effusion depends on the severity of the effusion and associated development of fetal distress or cardiac insufficiency as manifested by hydrops fetalis. Fetal hydrothorax is usually managed either in utero by thoracocentesis, thoracoamniotic shunt or postnatally by immediate intubation and thoracocentesis (12,13) and rarely by EXIT procedure (5), in order to prolong pregnancy and allow better lung development. It has been proven that EXIT supported thoracocentesis is of lowest risk with temporary preservation of the fetoplacental circulation allowing unhurried drainage of the thoracic cavities for lung expansion before birth. (14) Bouchard et al. (2) reported a 31-week gestation fetus with bilateral congenital cystic adenomatoid malformation associated with massive ascites, diagnosed by fetal ultrasound. The EXIT procedure was performed to relieve severe hydrops fetalis. After hysterotomy, prior to delivery of the baby, massive fetal ascites were removed. Complete atresia warranted fetal surgical tracheostomy. The uteroplacental bypass time was 25 minutes. (2)

The antenatal approach may not always be feasible due to an unacceptable risk as a result of fetal and placental position. Postnatal intubation and thoracocentesis may expose the neonate to permanent hypoxemic brain damage when thoracocentesis and further lung expansion for alveolar gas exchange fail. Henry et al. (15) revealed the important aspects of EXIT procedure used in management of hydrops fetalis: The mean time of detection was 27.3 ±5.6 weeks of gestation: 75% were detected during the third trimester, while a few cases were detected as early as 13-week gestation. The course varied from spontaneous resolution (22%) to favorable outcome after treatment (43%) and poor outcome (fetal/neonatal death) (35%). Those with unilateral pleural effusion, with no polyhydramnios or hydrops fetalis, were more likely to have spontaneous resolution. Hydrops was a risk factor of poor outcome, irrespective of bilateral effusions and gestational age at delivery. Therapeutic procedures like bronchoscopy, surfactant instillation, tracheotomy and tracheoplasty can be performed with the aid of the EXIT procedure by allowing establishment of airway via endotracheal intubation or by tracheostomy. The EXIT procedure for primary fetal hydrothorax took only 5-8 minutes. A longer duration of the EXIT procedure brought about difficulty for the anesthesiologist to maintain uteroplacental circulation and to keep the uterus relaxed.

Henry et al. (15) reported the EXIT procedure in 2 cases of fetuses with bilateral pleural effusion or poly-hydramnios, without hydrops fetalis or heart anomalies at 38-weeks gestation. Postnatal X-ray showed no evidence of plural effusion and normal lung parenchyma. Prontera et al. (16) reported a moderately macrosomic fetus with severe polyhydramnios, with isolated bilateral pleural effusions and with no cardiac malformations, in which an EXIT procedure was performed successfully at 38-week gestation. They suggested that the right hemithorax be drained first to minimize compression of the central veins by the opposite side.

By using EXIT, adequate ventilation can be achieved during the procedure with an expected excellent outcome. (5) Mothers and babies tolerated the EXIT procedure well, when the fetuses were in their 29-40-week gestition, without signs of fetal hemodynamic instability. (2) By comparison, maternal blood loss during the EXIT procedure was 848 mL, which was compatable to conventional cesarean section. (2) There might be 2 concerns of maternal anesthesia: 1) left uterine displacement for avoiding maternal hypotension and maintaining adequate maternal cardiac output, and 2) caution of volatile anesthetics for preventing decreases in maternal blood pressure and myometrial tone and decrease in fetal oxygenation. (10) Intrapartum complications in mothers occurred in 10% of cases and included hemorrhage, uterine atony, placental abruption, and dehiscence of a prior uterine scar. (17)

## CONCLUSIONS

The EXIT is a safe procedure under adequate fetal ventilation and uteroplacental circulation support. It is indicated for the management of several cardiothoracic diseases, including mediastinal or lung mass resection, drainage of pleural effusions, palliative treatment of critical congenital heart disease and establishment of EXIT-to-ECMO. EXIT has been attempted successfully in many centers, and it has been proven that mothers and babies tolerate the procedure well. Maternal and fetal surveillance during anesthesia is important to maintain maternal blood pressure and placental blood flow and fetal oxygenation.

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