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Ex Utero intrapartum treatment (EXIT)

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ABSTRACT

The anesthesia *ex utero* intrapartum treatment (EXIT) procedure is a specialized surgical procedure used to deliver babies who have airway compression due to cystic adenomatoid malformation, bronchopulmonary sequestration, cervical teratomas, or other congenital conditions. EXIT is erroneously known as a routine cesarean section (CS), but is rather an extension of CS with discernible differences. The procedure creates an opening in the anesthetized abdomen of the mother and uterus. Once EXIT is complete, the remainder of the CS proceeds. EXIT is much more complex than a routine CS, as it requires coordination between the mother and a multidisciplinary team of surgical and neonatal personnel. This review highlights current anesthetic concepts during the EXIT procedure.

Keywords: Caesarean Section; Airway; Vaginal Birth; Anesthesia; *Ex Utero* Intrapartum Treatment; EXIT

1. INTRODUCTION

As scheduled cesarean sections (CS) become safer, there has been a movement to perform CS upon maternal request [1,2]. Vaginal birth after caesarean (VBAC) is not associated with increased risk of maternal or neonatal mortality and has contributed to the increase in CS procedures in recent years [3-7]. However, a mother may refuse to undergo a CS in most countries. In the CS procedure, laparotomy occurs through a surgical incision made in the abdomen followed by a similar hysterotomy for the uterus. A hysterectomy consists of a CS followed by the removal of the uterus. There are several ways to perform CS. The traditional method involves a midline longitudinal incision. However, it is rarely performed today, as it is more prone to complications. Instead, the lower uterine segment section (USS) is used through a transverse cut just above the edge of the bladder, which results in fewer complications. USS may be done in cases of extreme blood loss or when the placenta is inseparable from the uterus. Repeat CS can occur and is typically performed through the old scar. Regional anesthesia is frequently delivered and general anesthesia is reserved for high risk cases or emergencies. However, the overall risks of general anesthesia for mother and baby are still extremely small. Recent studies did not link epidural anesthesia with any type of labor failure leading to CS, but the general medical practice is to use labor induction drugs after anesthesia to counteract sedative effects [8]. In terms of proper *ex utero* intrapartum treatment (EXIT) procedure, the infant is delivered attached to the umbilical cord and the placenta, while a surgeon establishes the airway to allow the infant to breathe. Once EXIT comes to completion, the umbilical cord can be clamped and the infant is delivered. The remainder of the CS proceeds, as EXIT requires coordination between the mother and specialists operation. The difficulty lies in preserving enough blood flow through the umbilical cord and protecting the placenta to avoid contractions of the uterus.

The basic principles of EXIT were developed for the initial purpose of reverse tracheal occlusion of the infant, especially for cases of severe congenital diaphragmatic hernia (CDH). EXIT provides the advantage of uteroplacental gas exchange but on placental support. Through the early development of EXIT, additional principles were gathered, which have improved outcomes, most notably in cases of airway obstruction. The prodroms of EXIT have expanded and now include giant fetal neck masses, lung or mediastinal tumors, congenital high airway obstruction syndrome, and EXIT to extracorporeal

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membrane oxygenation (ECMO) [9].

The EXIT procedure encompasses situations in which obstruction is already anticipated. Not only is EXIT useful in CDH with intrauterine tracheal occlusion, but additional indicators have been proposed. Reports of cases, which utilized the EXIT procedure, varied, but stress the importance of combining fetal ultrasound (US) and magnetic resonance imaging (fMRI) in the characterization of cervical masses and usefulness in programming the procedure with a multidisciplinary team. For instance, anesthesia of the mother can be induced with thiopental, succinylcholine, and fentanyl followed with intubation, and maintained with isoflurane and nitrous oxide [10]. Any abdominal midline incision should be followed with a low transverse incision of the uterus. Immediate laryngoscopy is a main indicator of an administered tracheostomy. Surfactant can be given after ventilation to facilitate compliant delivery [11]. After reducing the concentration of anesthetic, administration of oxytocin can help with uterine contractility establishment and avoidance of uterine atony in the postoperative period.

Case reports indicated the procedure of EXIT to ECMO for a fetus with CDH and cardiac defect, congenital high airway obstruction syndrome, resection of congenital cystic adenomatoid malformation of the lung on uteroplacental bypass, unilateral pulmonary agenesis, and thoracoomphalopagus conjoined twins. The average duration of uteroplacental bypass was 14.7-min to 30.3-min, during which hemodynamic instability is not recorded by fetal heart rate, pulse oximeter, or fetal echocardiography, except in rare cases. Blood loss through the mother is on average 574.1-mL to 848.3-mL [12]. In selected groups of infants with CDH, tracheal occlusion is still recommended to obstruct the normal flow of lung fluid and to stimulate lung expansion and growth. The solution is to arrange delivery to allow the occlusion to be removed and the airway secured, if the uterus is to be kept relaxed and the uteroplacental blood flow intact. The technique of tracheal occlusion remains under study in clinical trials [13].

Recent treatment of CDH suggests onset within 24 hrs of life and has likewise been a main concern. However, the use of modalities is dependent on the situation of each institution. Permissive hypercapnea respiration aims to avoid barotraumas in aspiration and has reportedly improved outcomes [14]. In terms of EXIT to ECMO, infants usually pass ventilation trials, but require ECMO within 48-hr before delivery. The overall survival morality of EXIT to ECMO is suggested to be around 64% [15]. With the assumption of severe CDH, EXIT to ECMO is associated with infants expected to have a poor prognosis under conventional techniques. In addition, it is reported through EXIT that postpartum wound complications are increased to around 15% with no effect on the rate of endometritis. In addition, there is no difference in hematocrit level change or postpartum hospital stay [16]. The presence of large fetal neck masses is one of the causes of airway obstructions. The relationship of the neck mass to airway structures can be established with US and fMRI. The EXIT procedure can be helpful in such cases and to obtain a fetal airway [17-19]. In particular cases of life-threatening fetal neck masses (consider CVR values between 2.1 and 4.5 at maximum size or between 1.9 and 3.6 near term) [20], EXIT with the course of diagnostic accuracy of imaging results, intraoperative complications and outcomes, can lead to polyhydramnios as a symptom. The possibility of wedging of the lungs is almost always a sign of detectible hyperextension. In addition, the chance of the trachea pulled up into the neck may lead to the underestimation of the site of tracheostomy. The occurrence of polyhydramnios is noted as a result of esophageal compression [9].

Fetal fMRI provides the most accurate diagnosis in most cases while ultrasonography can be used as an alternative [21]. It is evident for neck areas, especially the upper respiratory tract, that EXIT procedure can be indicated in selected cases and include exposure and temporary obstruction of the trachea to reduce the viscera and prevent pulmonary hypoplasia in CDH, prenatal tracheotomy in laryngeal atresia, and intranatal establishment of an airway in airway-obstructing embryonic tumors [21, 22]. It is necessary to utilize fMRI for evaluation of fetal neck masses prior to operation through the EXIT. With diagnosis either through fMRI, US, spin-echo, fast gradient-echo, or half-fourier single shot turbo spin-echo, the sequences were able to demonstrate fetal airway relative to the mass. In addition, the sequences were able to give a precise definition of the mass because of larger scopes of view, which would otherwise be obtained with only fMRI as opposed to US. The fast gradient-echo sequence is known to provide the most definition of a mass due to its decreased motion artifacts.

However, fMRI brings the most essential information about the anatomy of the fetal neck masses and the adjacent airways prior to selection for the EXIT procedure [23]. In general, fetal neck masses can present a major challenge with subsequent risks of hypoxia, brain injury, and death. A multidisciplinary approach combined with accurate imaging sequences is the main precedent of a successful outcome [24]. The EXIT procedure provides up to 1-hr of good uteroplacental support and is still a choice to secure an airway in a large neck mass [21]. Labor after CS is associated with a greater perinatal risk than CS without labor. A factor like prior VBAC is associated with a high rate of successful labor compared with patients without VBAC. For instance, US measurement of the lower uterine segment thickness is around 3.5-mm and is followed with a negative predictive value for uter-

ine defect risks [7]. In comparison with planned repeat low-transverse CS, VBAC is not shown to increase the risk of maternal or neonatal mortality [4]. In a study, which examined the infant risk associated with VBAC through examination of depressed Apgar score, the Apgar scores within 5-min suggested only insignificant differences between patients who delivered VBAC and those patients who delivered vaginally without CS. Infants in the VBAC group were more likely to have an umbilical arterial pH of no more than 7.1. VBAC poses a low level of risk to the infant, but the potential damage in fetal acidemia is unknown [6]. In addition, there is an insignificant difference in uterine rupture or bladder injury and with VBAC, a risk for composite adverse maternal outcome or transfusion is generally lower.

Among almost all VBAC, risk for overall major maternal morbidities and maternal fever is relatively low, so that physicians can make a favorable benefit-risk ratio explicit when counseling [3]. In looking at whether or not women were able to exercise informed choices to explore decisions about the method of delivery and how the choices are interpreted following the birth, expected mothers must have access to non-biased information in order to engage in a collaborative understanding with midwives and obstetricians. For women, psychological and social implications about VBAC may trump any physical concerns [1].

2. IMAGING AND DIANOSTICS

Antenatal ultrasound is commonly used to detect and surgically correct fetal masses, which requires intrapartum surgical intervention to save the fetus from future harm during full time birth. Specific anesthetic concepts are needed for ensuring umbilical perfusion [25]. If the diagnosis is accurately made through image sequencing, the EXIT procedure may be life-saving [26-29]. The most important concern of the anesthesiologist is the usage of deep volatile anesthesia for a prolonged period of time in combination with any necessary intravenous infusions. The hemodynamical stability of the mother is the main goal. Normal blood gas values in the umbilical artery means gas exchange is not negatively affected during EXIT [30]. Epidural anesthesia with monitoring allows surgery to take place without complications [31]. In numerous ways anesthetic considerations for EXIT procedures are identical to considerations for non-obstetric surgery during pregnancy, including concerns for the mother, avoidance of teratogenic drugs and asphyxia, and prevention of preterm labor. Anesthetic considerations also depend on the location of the placenta and distinct from maternal surgery for the EXIT procedure, and the infant is not considered for anesthetic interference [32]. Instead, the infant can be the primary patient along with the mother and complications can be effectively recognized, predicted, and avoided by monitoring. Monitoring is crucial for assessing the response to corrective maneuvers [33,34]. Occasionally, the bellows may pop-off the valve, even if the gas flow is turned off. This can be due to the ventilator entering the breathing circuit through leaks in the bellows. Therefore, testing the integrity of the bellows is suggested to avoid complications [35].

3. METHODOLOGY OF ANESTHESIA

In addition to the usual considerations of anesthesia in obstetrics, the special considerations for the EXIT procedure can be summarized to fetoplacental circulation through profound uterine relaxation and airway manipulations and controls [36]. As part of a planned EXIT procedure, a multidisciplinary team (obstetric and surgical personnel) to care for the mother, and neonatal surgical personnel to care for the infant, are equally needed [37]. All cases require the specialist airway skills of the pediatric anesthetist. As part of a multidisciplinary team involved in EXIT, the anesthetist may be suddenly called upon to secure a compromised airway when no antenatal diagnosis has been made. Still after elective surgical excision, airway compromise may occur and require intervention. There are several concerns to be addressed in all the postpartum, surgery, and postoperative stages, and the understanding of the techniques employed to overcome the potential difficulties are key [38]. In specific to the anesthetist, extracorporeal membrane oxygenation (ECMO) has in the past been found to significantly boost survival rates in infants with respiratory collapse cases, but there has been a decrease in the use of ECMO. Instead, the methods of high frequency oscillatory ventilation (HFOV), inhaled nitric oxide (iNO), and surfactant therapy are used [39-41]. The instances of ECMO utilization found within the past decades are likely obsolete and unmet for instances today. Moreover, data supports the increasing trend of HFOV, iNO, and surfactant over ECMO [42]. Recent case studies of the anesthetic management in high-risk EXIT cases are presented in **Table 1**.

4. METHODOLOGY OF FETAL SURGERY

There is a misconception that the EXIT procedure is the same as a CS, but the goals of the EXIT and CS differ. For instance, CS intents to maximize the uterine to prevent postpartum hemorrhage and minimize transplacental diffusion to avoid neonatal depression. Whereas, EXIT aims to achieve a state of uterine hypotonia to maintain uteroplacental gas exchange, preserve uterine volume, maintain maternal blood pressure, and avoid cardiac depression through the appropriated level of anesthesia [9].

Table 1. Applications of anesthetics & drug dosages in recent EXIT case studies.

Fetal disease state	Procedure used	Pre-op drugs relative reported dosages	Induction anesthestics and reported dosages	Anesthestic maintanence with relative reported dosages	Opiods and neuromuscular blockers/fetal anesthesia	Uterine relaxation	Reference
Congenital high airway obstruction syndrome (chaos) in twin gestation	1) EXIT 2) Laryngoscopy for neonate intubation 3) Tracheostomy	Pre-oxygenated	Rapid Sequence Induction (RSI): 1) Lidocaine (100 mg) 2) Propofol (200 mg) 3) Succinylcholine (120 mg)	**Operational closing:** 1) Midazolam (5 mg) 2) Propofol (100 mg) 3) Hydromorphone (1.2 mg) 4) Ondansetron (4 mg) 5) Neostigimine/ glycopyrolate (3 mg/0.6 mg) **In additional to maternal anesthesia fetus was given:** 6) Single injection directly into infant: Fentanyl (5 mcg/kg) Atropine (0.2 mg/kg) Rocuronium (1.5 mg/kg)	Vecuronium* *Dosage not reported	1) Desflurane* 2) Nitroglycerin infusion* *Dosages not reported	[44]
Cervical tumor of the neck	1) Cervical tumor resection 2) Tracheostomy 3) EXIT	1) Intravenous metoclopramide (10 mg) 2) Ranitidine (50 mg)	Rapid Sequence Induction (RSI): 1) Fentanyl (250 µg) 2) Propofol (150 mg) 3) Succinylcholine (50 mg)	2% Isoflurane with expired fraction of 1.4% in 100% oxygen Fentanyl (100 µg)	Atracurium (30 mg) for muscle relaxation	During procedure, uterine relaxation due to 2% isoflurane was satisfactory and it was, therefore, not necessary to use additional tocolytic agents	[65]
Large oral tumor	1) Tracheostomy 2) Laryngoscopy for neonate intubation 3) EXIT	Morphine for analgesia (100 µg)	Rapid sequence induction (RSI): 1) Fentanyl (150 µg) 2) Propofol (150 mg) 3) Succinylcholine (100 mg)	2.5% isoflurane, oxygen at 100% additional fentanyl (200 µg)	Atracurium (25 mg) for muscle relaxation	During the procedure, uterine relaxation was satisfactory and it was, therefore, not necessary to use additional tocolytic agents	[65]
Cesarean section of a twin gestation, one had a large epignathus	1) Tracheostomy 2) EXIT	**Not reported	Rapid sequence induction: 1) Propofol 2) Suxamethonium **Dosages not reported	3% sevoflurane in 100% oxygen	**Not reported	**Not reported	[66]
Cystic hygroma/ teratoma	1) Tracheostomy 2) Cystic hygroma resection 3) EXIT	**Not reported	Rapid sequence induction (RSI) with cricoid pressure: 1) Fentanyl (100 µg) 2) Sodium thiopental (370 mg) 3) Succinylcholine (120 mg)	2.0% sevoflurane in 100% oxygen	1) Subcutaneous terbutaline (40 µg) 2) Nitroglycerine drip was on standby 3) Rocuronium (20 mg) IV boluses to maintain no more than 1 to 2 twitches during train-of-four monitoring	Subcutaneous terbutaline (40 µg) was administered, and a nitroglycerine drip was on standby	[67]

Continued

Micrognathia glossoptosi, abnormal ears with preauricular tags, and ventricular septal defect ***Newborn died of sepsis and cardiac failure one month later***	1) Tracheostomy 2) EXIT	Intravenous (IV) metoclopramide (10 mg)	Rapid sequence induction: 1) Propofol (200 mg) 2) Remifentanil (20 µg) 3) Rocuronium (50 mg)	1) Combination of nitrous oxide (N_2O)/oxygen 0.6/0.4 and remifentanil infusion (1.0 mg of remifentanil diluted in 50 mL of 0.9% NaCl) titrated by syringe pump up to 0.8 µg/kg/min 2) Repeated 1.0 mg boluses of midazolam (total 5 mg for the procedure) were used to potentiate the hypnotic and amnestic effects of the remifentanil/N_2O combination 3) In addition to maternal anesthesia, fetus was given Fentanyl (30 µg)	In additional to maternal anesthesia fetus was given: intramuscular injection of rocuronium (3.0 mg)	Nitroglycerin (NTG) infusion was started after induction of anesthesia at 0.06 µg/kg/min and increased to 0.3 µg/kg/min	[68]
Cervical teratoma	1) Tracheostomy 2) EXIT	Pre-oxygenated	Rapid sequence induction (RSI): propofol or thiopental, fentanyl, and succinylcholine or rocuronium **Dosages not reported	Sevoflurane* *Dosage not reported	**Not reported	Initial sevoflurane was gradually increased to 5.5%	[69]
Large goitre	1) Tracheostomy 2) EXIT	**Not reported	Spinal-epidural (CSE) L3-L4: 1) Bupivacaine (12 mg) 2) Fentanyl (15 µg) 3) Morphine (150 µg) Intrathecally	Remifentanil initiated at 0.15 $\mu g \cdot kg^{-1} \cdot min^{-1}$	No muscle relaxation or anaesthesia was required for the fetus	i.v. bolus of Nitroglycerine (50 µg) followed by an infusion at 50 $\mu g \cdot min^{-1}$	[70]
Severe arthrogryposis	1) Tracheostomy 2) EXIT	**Not reported	Spinal-epidural (CSE) L3-L4: 1) Bupivacaine (12 mg) 2) Fentanyl (15 µg) 3) Morphine (150 µg) Intrathecally	Remifentanil infusion initiated at 0.1 $\mu g \cdot kg^{-1} \cdot min^{-1}$ and titrated up to 0.15 $\mu g \cdot kg^{-1} \cdot min^{-1}$	No neuromuscular blocking agents or analgesic adjuncts were needed	A nitroglycerin bolus of 100 ug i.v. followed by an infusion of 50 - 100 $\mu g \cdot min^{-1}$	[70]
Arthrogryposis with temporomandibular joint involvement and a hyper extended neck	1) Tracheostomy 2) EXIT	**Not reported	Spinal-epidural (CSE) L3-L4: 1) Bupivacaine (12 mg) 2) Fentanyl (15 µg) 3) Morphine (150 µg) Intrathecally	Remifentanil infusion was also started at that time at 0.10 $\mu g \cdot kg^{-1} \cdot min^{-1}$ and titrated up to 0.2 $\mu g \cdot kg^{-1} \cdot min^{-1}$	No neuromuscular blocking agents or analgesic adjuncts were needed	Nitroglycerin infusion was initiated (100 $\mu g \cdot min^{-1}$)	[70]
Anterior neck mass and polyhydramnios	1) Teratoma resection from neck 2) Tracheostomy 3) EXIT	**Not reported	Rapid sequence induction (RSI) 1) Thiopental sodium (3 mg/kg) 2) Succinylcholine (1.5 mg/kg)	1) Sevoflurane 2 - 3 vol% 2) Nitrous oxide in oxygen (50-50) combined with 3) Dose of Remifentanil (0.1 - 0.5 µg/min/kg) and rocuronium (50 mg total)	**Not reported	Two boluses of intravenous Nitroglycerine (30 µg), followed by an infusion at 0.5 - 1 µg/kg/min	[71]
Massive obstetric hemorrhage/ polyhydramnios and a fetal cervical teratoma	1) Tracheostomy 2) EXIT	1)Pre-oxygenated 2) Oral nifedipine (20 mg every 4 hr) 3) Subcutaneous terbutaline (0.25 mg)	Rapid sequence induction Propofol (180 mg) succinylcholine (100 mg) fentanyl 100 µg i.v. with cricoid pressure	Sevoflurane (1.5% - 2%) was administered with 50% oxygen and 50% nitrous oxide	Intermittent boluses of vecuronium	Intravenous Nitroglycerin (200 µg)	[72]

Continued

Tumoral mass on the anterior neck (cervical teratoma)	1) Hysterotomy 2) Tracheostomy 3) EXIT	1) Intravenous metoclopramide (10 mg) 2) Ranitidine (50 mg)	Rapid sequence induction: oxygenation with 100% under mask 1) Intravenous fentanyl (250 µg) 2) Propofol (140 mg)	Isoflurane in 2.5% concentration at 3% through gauged vaporizer and administered in mixture of O_2 and N_2O (50%)	Rocuronium (50 mg)	**Not reported	[73]
Cavernous lymphangioma large septate mass protruding into the hypopharynx and the distal portion of the nasopharynx	1) Tracheostomy 2) EXIT	**None reported	1) Thiopental (300 mg) 2) Succinylcholine (100 mg) 3) Fentanyl (50 ug)	0.4% - 2.5% sevoflurane in 100% oxygen	**None Reported	Magnesium sulfate* *Dosage not reported	[74]
Severe micrognathia and polyhydramnios	1) Tracheostomy 2) EXIT	**None reported	Rapid sequence induction: general anesthesia (with cricoid pressure) 1) Propofol, (150 mg) 2) Succinylcholine (100 mg)	1) 5% sevoflurane 2) 50% nitrous oxide & oxygen 3) Fentanyl (300 mcg)	Vecuronium (5 mg)	Nitroglycerin infusion (30 mcg/min)	[75]

In terms of preoperative considerations, the physiology of pregnancy contributes to a variety of risks. The mother is at risk for aspiration pneumonitis due to decreased pressure of the lower esophageal sphincter, the increased pressure of the gravid uterus on the stomach, and gastric acid production. In addition, the cardiovascular system takes a decrease in preload during supine positioning, and there is an expanded blood volume, lower hematocrit, and increased peripheral venous capacity. The pulmonary function likewise is affected through alterations in functional residual capacity, suggesting the increased chance of hypoxia. The anesthetics are used mainly to decrease myometrial tone intraoperatively, and there is an inhalation anesthetic regime administered. The first stage involves anesthesia maintenance at 0.5-MAC of desflurane, isoflurane or sevoflurane in oxygen, which is decreased to 0.2-MAC before maternal incision, then increased before hysterotomy when needed [43]. The second stage prevents uterine atony and excessive maternal bleeding through measures including decreased anesthetic to 0.5-MAC, followed by 20-U oxytocin in 500-mL saline and 10-U bolus in 1000-mL drip [9]. Before incision, a cocktail of fentanyl, atropine, and vecuronium is administered intramuscularly to provide for postoperative care [44].

5. EXIT INDICATIONS FROM KNOWN CONDITIONS

Several conditions are likely suitable for the usage of EXIT. In rare cases if diagnosed *in utero*, EXIT can be performed for amniotic band syndrome (ABS), if the congenital disorder starts to cause entrapment of fetal parts. However, unless to save a limb considered in serious danger of amputation or deformity, EXIT is typically not considered until identifiable vital organs or the umbilical cord are directly affected. Cervical teratomas (CT) are difficult tumors with high mortality and morbidity. Though most tumors are benign, CT must be dealt with through timely antenatal diagnosis and care must be taken to avoid upper airway obstruction. EXIT is cited through sources to one part of a structured approach to the treatment of CT [28,38,45].

Along with EXIT, fMRI for evaluation of giant fetal mass must be used as fMRI provides the essential information prior to selection for the EXIT [21,23,24]. Encephaloceles known to be abnormalities in the pediatric age group can likewise be treated. For the otolaryngologist, encephaloceles will mostly be encountered adjacent to the brain and in the nasopharynx, which might develop through mastoid surgery, trauma, or infections [46]. However, it is rare for encephaloceles to occur congenitally, but nonetheless, instances are found in the mastoid. It is relatively more common for fronto-ethmoidal encephaloceles to be found in about 1 in 10 of all encephaloceles [47]. The infant presented with cystic mediastinal mass or enlarged echogenic lungs can be treated with bronchoscopic evaluation during EXIT [15,48,49]. The presence of CDH in infants with liver herniation into the chest show prenatal repair with unsuccessful outcomes. In understanding the pathophysiology of CDH and its repair, the normal egress of fetal lung fluid enlarge the lungs and reduces herniated viscera, leading to improved pulmonary function. The development of methods to temporarily occlude the fetal trachea allows growth of the lungs and reverse obstruction, unplugging the trachea at the time of birth. Signs of improvements in the lungs *in utero*, with reversal of pulmonary hypoplasia, is docu-

mented after birth and temporary occlusion of the trachea accelerates growth of the lungs and ameliorates the pulmonary hypoplasia associated with CDH [50].

Cases of syringomyelia with coexisting hydrocephalus establish a pathogenic relationship between several conditions. It is reported that hydrocephalus can aggravate conditions through the hydraulic pressure effect [51,52]. Myelomeningocele is a congenital occurrence in the backbone and spinal canal and is a type of spina bifida associated with the lack of dietary folate or neural tube defects. Detection of neural tube defects can usually be done during pregnancy by AFP screening or detailed US, among other imaging [53-55]. Intrauterine surgery for myelomeningocele has also been performed and the safety and efficacy is currently being investigated. The incidence of spina bifida can be decreased significantly with dietary folate within three months of pregnancy. Sacrococcygeal teratoma (SCT) is a tumor located at the base of the coccyx. Specifically, SCT is a type of teratoma neoplasm belonging to a class of nonseminomatous germ cell tumor and is a result of abnormal development of pluripotent cells. SCT are idiopathic in terms of whether the condition is congenital and the pluripotent cell seem unimportant in the body [56,57]. Recent case reports should however be noted for other indications for the use of EXIT (**Table 1**).

6. FUTURE AND IMPROVEMENTS OF EXIT PROCEDURE

There are several rules for the future success and expansion of the EXIT procedure. In the short-term, the most important rule is accountability. The EXIT procedure has been concluded as an optimal strategy for delivery in multiple cases. In order for the EXIT procedure to become permanently established, patients must be randomized in clinical trials when applicable to demonstrate the benefits. In the long-term, it is predicted that the EXIT procedure, as now practiced, will be entirely eliminated. The uterine incisions with attendant risk and morbidity will likely be deduced or entirely minimized for less invasive procedures using superior imaging, instruments, and technological innovations and advances. In the same area, the developed method will likely be required to correct the specific defects with discrete interventions [58]. The randomized trails would need to be validated through outcome-based research [59,60]. Due to the rarity of anomalies or high mortality, it had been impractical or unethical to perform clinical trials, but it has become imperative that EXIT can be subjected to the scrutiny of randomized trails as found in fetoscopic laser separation cases and fetoscopic tracheal occlusion for diaphragmatic hernia. In addition, though present time fetoscopy is considered minimally invasive, there is consideration for treatment associated morbidity with minimal procedures [61,62]. Though procedures are currently performed fetoscopically, progress has been slow [63]. Ultimately, fetal imaging is the realization of immediate ultra-high resolution imaging in all aspects [58]. The procession of US and fMRI technologies seems most promising and the most modern is the high Tesla fMRI technologies, which achieves 25-µm resolution and provides internal and external anatomy [64]. Additionally, it has been suggested that Near-Infrared Spectroscopy (NIRS) can be used in the monitoring of fetal health during the EXIT procedure considering the advantageous ability of measuring hemoglobin oxygen saturation and umbilical venous oxygenation [44].

7. SUMMARY

While EXIT procedure is being used, advances have been made in both the neonatal and uteroplacental aspects surrounding CS. The methodology of EXIT from preoperative to postoperative care has improved drastically with the additional influx of information from recent research. It is now definitely known that the benefits of the procedure are formulated through accuracies in imagining diagnostics and accommodations to the needs of the mother through the multidisciplinary team of specialists, surgeons, and other personnel. With several conditions mentioned about the EXIT procedure, steps to avoid complications are known, and imperfections in the art are noted. The direction of the EXIT procedure will allow attendant risk and morbidity to be deduced, and methods will correct defects. As further information becomes accessible, the psychosocial concerns of women about CS and EXIT procedure will likewise be addressed, assuming CS can occur with the link of anesthesia in terms of proper EXIT procedure.

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