Case Reports/Case Series

Case series: Combined spinal epidural anesthesia for Cesarean delivery and *ex utero* intrapartum treatment procedure

[Série de cas : L'anesthésie rachidienne et péridurale combinée pour les interventions de césarienne et de traitement ex utero intrapartum]

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Purpose: To report the use of regional anesthesia and iv nitroglycerin to provide anesthesia and uterine relaxation for three Cesarean deliveries (CD) involving *ex utero* intrapartum treatment (EXIT) of potentially life-threatening airway obstruction in the newborn.

Clinical features: Case 1 - a 36-yr-old woman at 38 weeks' gestation was scheduled for an elective CD for fetal skeletal dysplasia and micrognathia. Case 2 - a 34-yr-old woman at 35 weeks gestation had a fetal ultrasound revealing fixed neck flexion and micrognathia consistent with fetal arthrogryposis. Case 3 - a 27-yr-old woman presented at 38 weeks gestation for CD for severe fetal micrognathia, with mandibular growth below the fifth percentile. For each case, a combined spinal epidural anesthetic was performed with 0.75% bupivacaine, fentanyl and morphine intrathecally followed by placement of a multiorifice epidural catheter. Prior to uterine incision patients received a loading dose followed by an iv infusion of nitroglycerin. Uterine relaxation was sufficient in all cases for delivery of the fetus, and allowed for evaluation by direct laryngoscopy and intubation while maintaining fetal-placental circulation. The surgical procedures were completed without incident.

Conclusions: Anesthesia and uterine relaxation for CD and EXIT procedures can be safely provided with regional anesthesia and iv nitroglycerin.

Objectif: Rendre compte du recours à l'anesthésie régionale et à la nitroglycérine iv pour la relaxation utérine dans trois cas d'accouchement par césarienne (AC) ayant nécessité le traitement *ex utero* intrapartum (EXIT – *ex utero* intrapartum treatment) d'obstruction potentiellement dangereuse des voies respiratoires du nouveau-né.

Éléments cliniques: Cas 1 – une femme de 36 ans à 38 semaines de gestation devait subir une césarienne élektive en raison d'une dysplasie squelettique et de micrognathie chez le fœtus. Cas 2 – une femme de 34 ans à 35 semaines de gestation dont l'échographie fœtale a révélé une flexion fixe du cou et une micrognathie associées à une myodystrophie fœtale. Cas 3 – une femme de 27 ans, à 38 semaines de gestation, est venue pour une césarienne en raison d'une micrognathie fœtale grave, avec croissance mandibulaire en dessous du cinquième centile. Dans les trois cas, une anesthésie rachidienne et péridurale combinée a été effectuée avec de la bupivacaine 0,75 % intrathécale, du fentanyl et de la morphine, suivie par l'insertion d'un cathéter péridural à orifices multiples. Avant l'incision utérine, les patientes ont reçu une dose de charge suivie d'une perfusion iv de nitroglycérine. La relaxation utérine a suffi dans tous les cas pour l'accouchement du fœtus, et a permis l'évaluation par laryngoscopie directe ainsi que l'intubation tout en maintenant la circulation fœtale et placentaire. Les chirurgies ont été effectuées sans incident.

Conclusion : L'anesthésie et la relaxation utérine pour césarienne et EXIT peuvent être fournies en toute sécurité par une anesthésie régionale et une perfusion de nitroglycérine.

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THE *ex utero* intrapartum treatment (EXIT) procedure allows for controlled management of potentially life-threatening airway obstruction in the newborn. The EXIT procedure involves partial delivery of the fetus and maintenance of fetal-placental circulation allowing for management of the obstructed fetal airway with direct laryngoscopy, bronchoscopy, or tracheostomy. While this procedure originally gained popularity for establishing a patent airway and removal of tracheal occluding plugs used for the treatment of congenital diaphragmatic hernia,¹ indications have now grown to include a variety of congenital airway obstructions.²⁻⁷

A deep general anesthetic with halogenated agents has been the anesthetic technique of choice for EXIT procedures. The halogenated agents provide the necessary uterine relaxation for partial fetal delivery and preventing placental disruption while also providing fetal anesthesia.^{5,8,9} Neuraxial anesthesia has been reported sparingly in the anesthesia literature for the EXIT procedure.¹⁰ We present three cases where neuraxial anesthesia was used successfully for Cesarean deliveries (CD) involving EXIT procedures. Approval for the use of personal health information contained in this manuscript was obtained in accordance with Duke University Medical Center Institutional Review Board guidelines.

Case presentations

Case 1

A 36-yr-old gravida 4 para 1 woman presented at 37 weeks' gestation with spontaneous rupture of membranes and active labour. She had been scheduled to undergo an elective CD for fetal skeletal dysplasia. The patient had a history of type 1 diabetes, chronic essential hypertension and mild superimposed pre-eclampsia with this pregnancy.

A fetal ultrasound done at 34 weeks gestation revealed a cephalic fetus with marked polyhydramnios and rhizomelic short limbs. Three-dimensional images of the fetal face suggested micrognathia.

At 38 weeks gestation the patient went to the operating room. Following pretreatment with sodium citrate 30 mL orally, a combined spinal epidural anesthetic (CSE) was performed in the sitting position with 1.6 mL 0.75% bupivacaine, 15 µg fentanyl and 150 µg morphine administered intrathecally, followed by placement of a multiorifice epidural catheter. Oxygen 6 L·min⁻¹ was given through a face mask. Twenty-six minutes elapsed between induction of anesthesia and uterine incision. Prior to uterine incision the patient was given nitroglycerin 100 µg *iv* and an infusion of nitroglycerin *iv* was started at 1

µg·kg⁻¹·min⁻¹. Maternal hypotension did not occur and no vasopressor support was required. Uterine relaxation was sufficient for partial delivery of the fetus and evaluation by direct laryngoscopy and intubation by the otorhinolaryngology (ENT) surgeon while maintaining fetal-placental circulation. We attempted to monitor the oxygen saturation with a pulse oximeter on the fetal hand but could not obtain a reliable reading. The fetus had minimal mandibular movement but the epiglottis was easily visualized, therefore the ENT and neonatal intensivist elected to extubate the fetus, complete the delivery, and reevaluate the newborn. Once the umbilical cord was clamped and the newborn delivered, the nitroglycerin infusion was halted. The patient received 10 U of oxytocin *iv* followed by an infusion of 10 U·hr⁻¹ *iv*. The EXIT portion of the delivery took approximately six minutes and uterine tone was appropriate for the procedure. Adequate uterine tone was quickly achieved following the administration of oxytocin. The newborn, with an Apgar score of 2/10 at one minute was subsequently intubated by the neonatal intensivist without incident. The five-minute Apgar score was 9/10.

The surgical procedure was completed without incident and the estimated blood loss was 1000 mL. The patient was comfortable throughout the procedure.

Case 2

A 34-yr-old gravida 1 para 0 woman presented at 30 weeks and four days gestation for her first prenatal visit. Her past medical history was unremarkable. A fetal ultrasound revealed a breech presentation along with multiple skeletal abnormalities including fixed neck flexion, fixed position of upper and lower extremities, and micrognathia consistent with fetal arthrogryposis. Fetal echocardiography confirmed normal cardiac anatomy and function.

After consultation with ENT surgeon, the patient was taken to the operating room at 35 weeks gestation for a CD and EXIT procedure with the plan of performing direct laryngoscopy and possible bronchoscopy. Following pretreatment with sodium citrate 30 mL orally, a CSE was performed in the sitting position with 1.5 mL 0.75% bupivacaine, 15 µg fentanyl and 150 µg morphine intrathecally, followed by placement of a multiorifice epidural catheter. Shortly after injection of the intrathecal medication, four boluses of phenylephrine 100 µg *iv* were required to maintain a systolic blood pressure greater than 100 mmHg. Oxygen 6 L·min⁻¹ was given via face mask. Twenty-two minutes elapsed between induction of anesthesia and uterine incision. Immediately prior to uterine incision the patient was given nitroglycerin

100 µg *iv* followed by an infusion at 1 µg·kg⁻¹·min⁻¹. Prior to uterine incision the patient's hemodynamic status had normalized and no further phenylephrine was required during the EXIT component of this procedure. Uterine relaxation was sufficient for delivery of the breech fetus. While maintaining fetal-placental circulation, the fetus was evaluated and the trachea intubated by the ENT surgeon via direct laryngoscopy. Similar to case 1, we were unable to monitor the oxygen saturation reliably. The fetus was given ketamine 20 mg *im* prior to tracheal intubation. The epiglottis was easily visualized, and the trachea was intubated with moderate difficulty. Once the fetus was intubated, the umbilical cord was clamped and the newborn delivered. The EXIT procedure lasted five minutes and the newborn had Apgar scores of 2 and 9 at one and five minutes respectively. There was mild uterine hypotonicity despite 5 U of oxytocin *iv* followed by an infusion of 40 U·hr⁻¹ *iv*, therefore the patient received methylergonovine 200 µg *im*. The surgical procedure was completed without incident and the estimated blood loss was 1000 mL. The patient was comfortable throughout the procedure.

Case 3

A 27-yr-old gravida 4 para 2 woman presented at 38 weeks and five days gestation for elective CD and EXIT procedure due to multiple fetal anomalies.

A fetal ultrasound was performed at 31 weeks gestation for mild antepartum bleeding. Multiple fetal anomalies were evident including a left congenital diaphragmatic hernia, agenesis of the corpus callosum, ventriculomegaly, and ambiguous genitalia. Images of the fetal face suggested severe micrognathia, with a mandible below the fifth percentile for growth. Fetal echocardiography revealed a secundum atrial septal defect, dilated right atrium and ventricle, tricuspid regurgitation, and elevated right heart pressures likely secondary to pulmonary hypoplasia.

A multidisciplinary conference was conducted and an EXIT procedure with regional anesthesia was planned. The patient was taken to the operating room following pretreatment with sodium citrate. After obtaining *iv* access, an arterial catheter was placed in her non-dominant radial artery. A CSE was performed in the sitting position with 1.6 mL 0.75% hyperbaric bupivacaine, 15 µg fentanyl and 200 µg morphine intrathecally, followed by placement of a multiorifice epidural catheter. Oxygen 6 L·min⁻¹ was given via face mask. Twenty-nine minutes elapsed between induction of anesthesia and uterine incision. Prior to uterine incision the patient was given nitroglycerin 50 µg *iv* and an infusion of nitroglycerin *iv* was started at 0.5 µg·kg⁻¹·min⁻¹

FIGURE Confirmation of successful intubation with a neonatal carbon dioxide colorimetric device during an *ex utero* intrapartum treatment procedure.

and titrated to 1.5 µg·kg⁻¹·min⁻¹. A phenylephrine infusion was titrated (0.05–0.1 µg·kg⁻¹·min⁻¹) to prevent maternal hypotension. Uterine relaxation was sufficient for partial delivery of the fetus. The ENT surgeon was able to perform direct laryngoscopy with a rigid bronchoscope and successfully intubate the fetal trachea while maintaining fetal-placental circulation. Fentanyl, rocuronium, and atropine were available in a sterile syringe if needed. After confirmation of endotracheal tube placement by a carbon dioxide colorimetric device and repeat laryngoscopy (Figure), the fetus was delivered and transferred from the sterile field. The EXIT portion of the delivery took approximately five minutes and uterine relaxation was appropriate for the procedure. We did not attempt to monitor fetal oxygen saturation immediately, however a sterile probe was available on the sterile field if the procedure was prolonged. Once the umbilical cord was clamped and the newborn delivered, the nitroglycerin and phenylephrine infusions were halted. The patient was then given 5 U of oxytocin *iv* followed by an infusion of 35 U·hr⁻¹ *iv*. Uterine tone was excellent. The newborn, with Apgar scores of 2 and 5 at one and five minutes respectively, was taken to the neonatal intensive care unit where jet ventilation and invasive monitoring was established.

The surgical procedure was completed without incident and the estimated blood loss was 1000 mL.

Discussion

We report three cases in which neuraxial anesthesia was used for the management of CD involving an EXIT procedure.

Prenatal diagnosis of potentially life threatening airway obstruction enables controlled delivery, preservation of uteroplacental gas exchange, and treatment of the obstruction. The EXIT procedure was initially a means of removing fetal tracheal clips that had been placed to occlude the fetal trachea in the treatment of severe congenital diaphragmatic hernias. This procedure's indications have grown to include a variety of pathologies including fetal neck masses, congenital high airway obstruction, and dysgnathia complex.²⁻⁷

Management of the EXIT procedure requires extensive multidisciplinary planning and coordination involving the obstetric, anesthetic, ENT, and pediatric teams. In addition to the usual anesthetic considerations for any CD, specific aims for the EXIT procedure include attaining maximal uterine relaxation and fetal anesthesia. Uterine relaxation is necessary to prevent placental separation from the endometrium, thereby maintaining placental perfusion and fetal oxygenation allowing the delivery, either partial or full, of the fetus and appropriate airway management.^{1,4-6,8,11}

Since the inception of fetal surgery in 1981, relatively high concentrations of volatile anesthetics (1.5–3 minimal alveolar concentration) have been used routinely to provide surgical tocolysis.^{8,12} The literature is replete with case reports of general anesthesia for EXIT procedures.^{1-7, 9,11-14} This consists of high concentrations of inhaled halogenated agents and nitroglycerin for supplemental uterine relaxation if required. Unlike a routine CD, anesthesia is induced in advance to ensure adequate uterine relaxation, and there is no attempt to limit the induction to delivery time. Maternal mean arterial pressure is maintained with ephedrine or phenylephrine to maintain uterine perfusion pressure. Some institutions infuse crystalloid into the uterine cavity to preserve uterine volume to aid in preventing placental separation.^{2,6,11} Fetal anesthesia may be supplemented with *im* opioids, ketamine, and muscle relaxants.⁸ Epidural catheters have been placed for perioperative analgesia, but regional anesthesia has not been commonly used as the sole anesthetic modality.^{8,12}

Neuraxial anesthesia is currently the anesthetic technique of choice for CD.^{15,16} General anesthesia for CD is associated with higher morbidity and mortality from failed intubation and ventilation and aspiration of gastric contents.¹⁷ Neuraxial anesthesia, despite being associated with lower morbidity and greater patient satisfaction, has infrequently been used as the sole anesthetic technique for an EXIT procedure.^{10,18} When neuraxial anesthesia is used for EXIT procedures, surgical tocolysis can be provided quickly (within 30–60 sec) and effectively with *iv* nitroglyc-

erin.¹⁹ The latter has been used effectively to provide uterine relaxation in cases of breech extraction, manual removal of retained placenta, and an entrapped fetal head.⁸ The main side effect of nitroglycerin is hypotension. However, this can be easily corrected with the administration of vasopressors. In addition, nitroglycerin's short duration of action (60–120 sec) allows for rapid reversal of its effects once administration is discontinued after cord clamping and administration of oxytocic drugs.¹⁹ A number of dosing regimens have been described in the literature, but a common regimen has been similar to the one that we used: a loading dose of 50–100 µg, with continuous dosing as needed to maintain uterine relaxation.

We administered oxygen via face mask in an attempt to optimize fetal oxygenation. While some previous reports recommended giving 100% oxygen,^{1,5,9} an inspired oxygen concentration of 50% also provided adequate fetal oxygenation.^{6,11} In retrospect, it would have probably been prudent to administer 100% oxygen, especially since we were unable to reliably monitor the fetal oxygen saturation during the procedure. In the first two cases we attempted to monitor fetal oxygen saturation but it was difficult, since the skin was not dry and the fetus was continuously handled by the surgeons.

Various methods have been previously employed to provide fetal anesthesia during the procedure, including the use of high inspired concentration of inhaled agents, or *im* administration of muscle relaxants and narcotics.^{1,4,5,8,11,12} In all of our cases, the ENT surgeons predicted that the procedure would last no longer than ten minutes. Ketamine, opioids, and muscle relaxants were available to be given *im* as required, and ketamine was administered in the second of the three reported cases.

In summary, we performed neuraxial anesthesia on three parturients presenting with fetal abnormalities requiring an EXIT procedure for the management of possible congenital airway anomalies. Neuraxial anesthesia in conjunction with *iv* nitroglycerin provided a safe means of delivering maternal anesthesia, while providing appropriate conditions for the EXIT procedure.

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