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Anaesthesia for open fetal surgery: Myelomeningocele repair

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INTRODUCTION

Fetal surgery is a rapidly evolving field that offers life-saving interventions and improved quality of life for unborn babies with congenital abnormalities.[1] Myelomeningocele, the most severe form of spina bifida, is a common neurologic condition with proven benefit from prenatal repair. Intrauterine interventions require a collaborative effort from a diverse multidisciplinary team to ensure the health and safety of both the expectant mother and the developing fetus.

The Mater Mothers' Hospital began fetal surgery in 2001, performing more than 400 cases to date. This includes 25 open myelomeningocele repairs, the most common open fetal surgery. As of 2018, the Mater was one of 34 hospitals globally performing this procedure[2] and remains the sole Australasian referral centre for open fetal surgery. As additional centres around the world prepare to offer fetal surgery, it is important to understand the perioperative considerations of these complex interventions.

OBJECTIVES

This article will provide a brief overview of fetal surgery, followed by a discussion on myelomeningocele, highlighting the key maternal, fetal and anaesthetic considerations specific to open fetal surgery for its repair.

MATERNAL-FETAL SURGERY OVERVIEW

In 1982, the International Fetal Medicine and Surgery Society published criteria for fetal disorders amenable to in-utero intervention.[3] These included the availability of accurate fetal diagnosis and staging, an individualised prognosis, lack of effective postnatal treatment, proven feasibility of in-utero surgery and involvement of a specialised multidisciplinary team.[4] Over the past two decades, there has been significant growth in the number of fetal surgical indications and procedures. Broadly, fetal surgery can be categorised into minimally invasive, open, and ex-utero intrapartum treatment (EXIT) procedures.[5] Table 1 provides an overview of common fetal surgical procedures.

Minimally invasive procedures

Minimally invasive maternal-fetal interventions include both ultrasound-guided procedures and fetoscopic surgery; the latter involves percutaneous placement of trocars through the uterus. The most common fetoscopic procedure performed at Mater is laser photocoagulation for twin-twin transfusion syndrome and is typically conducted under local anaesthesia with sedation.

Open procedures

Open maternal-fetal surgery involves the induction of general anaesthesia and the performance of a maternal laparotomy for uterine exposure. Hysterotomy or fetoscopy is then performed to allow surgical correction of the fetal defect. Upon completion, the uterus and abdomen are closed, and the pregnancy continues. Fetal myelomeningocele repair is the most common indication for open maternal-fetal surgery.

EXIT procedures

The EXIT procedure is a surgical procedure used to deliver babies with significant airway or lung compression. It involves operating on the fetus while the uteroplacental circulation remains intact to provide oxygenation, followed by delivery at the completion of the procedure.[6,7]

Table 1. Indications for common fetal surgical procedures
Adapted from Weber and Kranke, 2019 and Chatterjee et al, 2021

Type of fetal surgery	Indication	Procedure	Type of anaesthesia
Minimally invasive – USS guided	Fetal genetic testing	Percutaneous umbilical blood sampling	LA
	Fetal anaemia	Intrauterine transfusion	LA
	Aortic stenosis with evolving hypoplastic left heart syndrome	Balloon valvuloplasty	Neuraxial or general anaesthesia
Minimally invasive – fetoscopic	Twin-twin transfusion syndrome	Laser photocoagulation	LAWS or neuraxial
	Amniotic band	Surgical release	LAWS or neuraxial
	Congenital pulmonary airway malformation (CPAM)	Thoracoamniotic shunt	LAWS or neuraxial
	Bladder outlet obstruction	Vesicoamniotic shunt	LAWS or neuraxial
	Congenital diaphragmatic hernia	Fetal endoluminal tracheal occlusion	LAWS or neuraxial
	Spina bifida	Myelomeningocele repair (total percutaneous approach)	General anaesthesia
Open - laparotomy with hysterotomy or uterine fetoscopy	Spina bifida	Myelomeningocele repair	General anaesthesia +/- neuraxial
EXIT procedure	Oropharyngeal mass/neck mass/severe micrognathia	Securing airway	General anaesthesia
	CPAM/bronchogenic cyst/ sacrococcygeal teratoma	Resection of malformation/ cyst	General anaesthesia

*LA = Local Anaesthesia; LAWS = Local Anaesthesia With Sedation; USS = Ultrasound Scan

MYELOMENINGOCELE CORRECTION

Spina bifida is the most common congenital malformation of the neural tube, affecting approximately 1 in 1000 births worldwide.[8] It is characterised by failure of the neural tube to close during the fourth week of gestation.[9] Myelomeningocele is the most common and severe form of spina bifida, and is defined by the extrusion of the spinal cord and meninges through a bony defect without overlying skin.[9,10] It is associated with Chiari Type 2 malformation and subsequent hydrocephalus, commonly requiring management with a ventriculoperitoneal shunt. The level of the lesion determines the extent of neurologic impairment, which may result in lower limb weakness, altered sensation or paralysis, as well as bladder, bowel and sexual dysfunction.[10]

Neurologic deficits associated with myelomeningocele may arise from two pathways – the primary developmental abnormality of the spinal cord and secondary damage to neural tissue from exposure to amniotic fluid and trauma in utero.[10]

Historically, there were two options for managing a pregnancy complicated by spina bifida: termination or delivery followed by postnatal repair.[10] Advances in fetal surgical techniques now enable in-utero repair of myelomeningocele, potentially reducing secondary neurologic damage and improving long-term comorbidities.[11]

In 2011, the landmark Management of Myelomeningocele Study (MOMS)[12] compared open prenatal surgical repair between 19- and 26-weeks' gestation with standard postnatal repair. It found prenatal repair decreased the rate of death or need for ventriculoperitoneal shunt placement at 12 months. Prenatal surgery also improved mental function, motor scores and ambulation at 30 months and decreased the incidence of hindbrain herniation.[12] However, prenatal surgery was associated with earlier delivery (34.1 weeks versus 37.3 weeks) and increased incidences of preterm delivery, uterine dehiscence at delivery, placental abruption (6.6% versus nil) and maternal pulmonary oedema (5.5% versus nil).[13]

Longer-term follow-up of the MOMS participants at school age showed persisting sensorimotor benefits, decreased incidence of Chiari malformations and hydrocephalus, fewer shunt placements and shunt revisions compared to postnatal repair. Quality of life and family impact metrics were significantly improved.[14]

Following the MOMS, in 2014, the Maternal-Fetal Management Taskforce published guidelines for fetal myelomeningocele repair centres.[15] These include a multidisciplinary approach to care with around-the-clock access to a specialised spina bifida team, neonatal intensive care, experienced maternal-fetal medicine specialists, an ethics review board, and patient advocates. Patients should receive thorough counselling on options (including pregnancy termination and pre or postnatal myelomeningocele repair) covering risks for both the baby and the mother. Long-term standardised paediatric treatment and evaluation services should also be available.

PREOPERATIVE CONSIDERATIONS

The multidisciplinary team

Optimising maternal and fetal outcomes requires a coordinated group of specialised healthcare workers. This routinely comprises maternal-fetal medicine, neonatology, paediatrics (including clinical genetics), anaesthesia, neurosurgery, plastic and reconstructive surgery, radiology, perioperative nursing, midwifery, and social work.[5] An ethics committee typically oversees the creation of a fetal surgical service. Collaboration of the entire team is required to fulfil the preoperative considerations outlined in Table 2.

Table 2. Preoperative considerations for open myelomeningocele repair

Preoperative considerations
Maternal and fetal evaluation
Multidisciplinary counselling of maternal and fetal risks
Surgical and facility preparation – environment and equipment
Plan for potential fetal resuscitation or emergent delivery
Crossmatched blood available for fetal or maternal transfusion

Patient selection

Maternal-fetal medicine specialists conduct a detailed review of the maternal and fetal state to determine eligibility. This includes fetal MRI to assess the severity of spinal and intracranial pathology, fetal ultrasound to investigate co-existing malformations, and fetal echocardiography.[16] Fetal genetic studies, including karyotyping and microarray, may be performed to rule out chromosomal abnormalities, microdeletions or microduplications which contraindicate surgery.[17,18]

Maternal considerations

The anaesthetist's initial role involves assessing maternal suitability for surgery and providing counselling. Preoperative anaesthetic review allows adequate provision of information, helps facilitate rapport and allay maternal anxieties. Evaluation should focus on both physiologic and pathologic conditions associated with pregnancy. A thorough history and examination should be conducted, including an assessment of the mother's spine. Given the potential for catastrophic blood loss, a blood group with antibody screening should be arranged, with further investigations dependent on specific clinical concerns.[16] It is routine to discuss standard fasting procedures, general anaesthesia, arterial cannulation, spinal and epidural procedures, analgesia and the expected postoperative course.[11]

Although women may be physically well, the psychological impact of fetal surgery can be profound. Anxiety regarding an uncertain fetal outcome, the lack of direct maternal benefit, and the need to travel long distances to specialist centres often contribute to feelings of isolation. Balancing geographical access with the maintenance of case volume for resource-intensive procedures remains a challenge.[19]

Fetal considerations

Considerations for fetal surgery must account for a range of clinical, socio-cultural, legal and ethical concerns.[20] With a decision to proceed, an assessment should be made regarding the eligibility of the fetus for resuscitation in the event of fetal distress or need for emergent delivery.[21] Comprehensive counselling with parents is essential and should include informed consent for fetal resuscitation based on individual risks and values.

Fetal heart rate, position, and placental location should be evaluated before commencing anaesthesia.[5] A preoperative estimate of fetal weight is useful for calculating intraoperative fetal drug doses.

INTRAOPERATIVE CONSIDERATIONS

There are three main surgical approaches to myelomeningocele repair. Open repair involves maternal laparotomy, exteriorisation of the uterus and hysterotomy aided by resorbable staples. Fetoscopic repair via maternal laparotomy involves exteriorisation of the uterus followed by placement of uterine trocars to facilitate fetoscopy. Total percutaneous fetoscopic repair avoids the need for maternal laparotomy. A systematic review in 2018 showed no significant differences in fetal mortality or rates of shunt placement for hydrocephalus between surgical approaches.[22] Percutaneous fetoscopy was associated with higher rates of dehiscence and CSF leak at the fetal myelomeningocele repair site that required subsequent postnatal intervention (30 vs 7 per cent). There was also a greater incidence of premature rupture of membranes (79 vs 6 per cent) and preterm birth. Open repairs were associated with higher rates of uterine dehiscence (11 vs 0 per cent).[22,23] Given the risk of uterine dehiscence and rupture, performing a hysterotomy for open myelomeningocele repair mandates that all future pregnancies be delivered via caesarean section.[11]

Depending on the surgical approach, various anaesthetic techniques may be used for myelomeningocele repair. While there is limited evidence for the superiority of a specific technique,[5,24] understanding the impact of interventions on maternal and fetal outcomes is crucial. Intraoperative goals for open fetal surgery include managing uterine tone, maintaining uteroplacental circulation, optimising surgical conditions, monitoring fetal haemodynamics, and minimising risks to both mother and fetus.[25] At our institution, two senior anaesthetists work together to care for the mother and fetus. Table 3 outlines the salient intraoperative considerations for anaesthesia for open myelomeningocele repair.

Table 3. Intraoperative considerations for open myelomeningocele repair

Intraoperative considerations	
Access	Two large-bore peripheral IV cannulae Arterial line
Antibiotics	Broad spectrum coverage with cefazolin and azithromycin
Maternal monitoring	Standard ANZCA monitoring Cardiac output monitoring via arterial pulse contour analysis to optimise uterine blood flow BIS Temperature Neuromuscular monitoring to ensure adequate reversal prior to extubation Urine output
Fetal monitoring	Ultrasound • Umbilical artery doppler • Intermittent fetal echocardiography
Environment	Latex-free to prevent fetal exposure
Analgesia	Thoracic epidural placed pre-induction, loaded with ropivacaine prior to emergence Spinal anaesthesia pre-induction (0.5% heavy bupivacaine, fentanyl, clonidine)
Maternal anaesthesia	Modified RSI with left-lateral tilt Maintenance with sevoflurane
Uterine tone	Magnesium 10 mmol bolus (prior to exteriorisation of uterus and again prior to uterine closure) Volatile (up to 2 MAC at time of hysterotomy) GTN (third-line if required)
Maternal haemodynamics	Peripheral adrenaline and phenylephrine to maintain MAP
Amniotic fluid replacement	Infusion of warmed crystalloid solution (volume guided by USS)
Fetal anaesthesia	Intramuscular fentanyl and vecuronium

Maternal considerations

As for all obstetric patients, physiologic changes of pregnancy necessitate specific anaesthetic considerations. This includes securing a definitive airway given the increased risk of aspiration, and consideration of left uterine displacement to facilitate adequate venous return.[11,26] Ventilation should account for the physiologic increase in tidal volume and minute ventilation during the second trimester, noting that hypocarbia may cause uterine vasoconstriction and should be avoided.

Uterine tone

Profound uterine relaxation is required for hysterotomy. In open fetal surgery, high-concentration volatile anaesthetics (1.5-2.5 MAC) have historically been used for the maintenance of anaesthesia. Volatiles reduce uterine tone in a dose-dependent manner,[27] with concentrations greater than 2 MAC effectively minimising myometrial contraction to stimuli. However, such concentrations cause significant reductions in maternal cardiac output and uterine blood flow by up to 30 per cent.[28] Additionally, high-concentration volatile anaesthesia has been associated with fetal cardiac depression as well as maternal seizure activity.[29,30]

Multimodal uterine relaxation aims to avoid the risks of high doses of single agents. Varying combinations of volatile anaesthesia, glyceryl trinitrate (GTN), propofol, magnesium and remifentanil have been described to achieve adequate anaesthesia and tocolysis.[31-33] Surgical palpation provides useful feedback on the degree of uterine relaxation. GTN may be administered in boluses of 50-100 mcg or by a continuous infusion of 0.5-1 mcg/kg/min in cases of insufficient tocolysis.[34] Magnesium administration reduces volatile anaesthetic requirements, facilitates tocolysis, and provides fetal neuroprotection in the event of preterm labour.[35,36]

When administered at maternal skin incision as opposed to at uterine closure, magnesium was associated with a significant reduction in MAC and fetal volatile anaesthetic exposure, with no difference in vasopressor requirements or blood loss.[35] A retrospective analysis of 22 open myelomeningocele repairs found that intraoperative remifentanil infusions were associated with lower volatile anaesthetic requirements and reduced vasopressor use while maintaining adequate uterine relaxation, with no adverse effects on fetal outcomes.[37] By reducing volatile anaesthetic exposure, remifentanil may help to minimise fetal cardiac dysfunction.[24]

Haemodynamics

Maternal cardiac output can increase by up to 50 per cent during pregnancy.[38] Mean arterial pressure (MAP) may fall due to a reduction in systemic vascular resistance. As uteroplacental blood flow is not autoregulated, it primarily depends on maternal cardiac output.[38] Since many drugs used for uterine relaxation also cause hypotension, vasopressors and inotropes are used to keep MAP within 10 per cent of maternal baseline to maintain fetal perfusion.[11] Phenylephrine may have favourable effects on fetal acid-base status,[39] while ephedrine and glycopyrrolate are helpful in maintaining maternal heart rate and cardiac output. Adrenaline similarly helps maintain maternal cardiac output, with the added benefit of tocolysis due to beta-2 adrenoreceptor agonist effects.

In addition to an arterial line, advanced cardiac monitoring such as the FloTrac system™ (FloTrac; Edwards Lifesciences, Ivine, CA, USA) allows for estimates of parameters such as cardiac output index and stroke volume variation. Although it is yet to be validated in this group, advanced cardiac monitoring may be useful in guiding fluid replacement therapy in the context of hypotension. This is particularly important given the risk of postoperative pulmonary oedema following open myelomeningocele repair.[40] For this reason, many centres advocate restricting intravenous fluid volume to less than two litres.[11] The use of colloids, while not routine, may have fluid-sparing effects.

Other maternal considerations

Other routine anaesthetic considerations for the obstetric patient should be followed, including appropriate antibiotics and venous thromboembolism prophylaxis. Azithromycin provides broad-spectrum antibiotic coverage and readily crosses the placenta. Maintenance of normothermia is paramount, as the fetus is unable to autoregulate temperature, and hypothermia may trigger fetal bradycardia.[11] The use of magnesium for uterine relaxation can potentiate neuromuscular block. Hence, neuromuscular monitoring should be used to ensure adequate reversal of muscle relaxation prior to extubation. As the relaxed uterus is prone to haemorrhage (especially during hysterotomy and uterine stapling), large-bore IV access is prudent. Fortunately, the need for blood transfusion is rare.[34] Uterotonics should be emergently available in the event of conversion to caesarean delivery.[5] The risk of imminent delivery poses an enhanced risk of postpartum haemorrhage in the presence of uterine relaxation.[41]

Fetal considerations

Fetal anaesthesia and analgesia

Whether a fetus experiences pain during surgery, and at what gestation, remains a complex debate. Fetal stress responses are elicited as early as 18 weeks in the pituitary-adrenal, sympatho-adrenal and circulatory systems, independent of maternal responses.[42-44] By 19 weeks, reflex withdrawal to a painful stimulus occurs.[45] Although these responses are attenuated by opioid administration,[42] this is not synonymous with adequate analgesia. The complex development of the higher cortical structures required for pain perception suggests that pain perception is unlikely before 24 weeks.[45] Electroencephalogram studies at 24 weeks demonstrate cortical activity only 2 per cent of the time, as opposed to 80 per cent at 34 weeks.[46] Therefore, although the pathways may exist at 24 weeks, nociceptive signals may not equate to pain perception. While volatile anaesthetics and opioids readily cross the placenta,[5,25] long-term effects of fetal stress and pain remain unknown. From mid-gestation onward, there is a general tendency to err on the side

of caution and provide direct fetal analgesia.[5,47] Fetal analgesia can improve surgical conditions by reducing fetal movement,[48] and can be delivered by maternal transfer or directly to the fetus. Fentanyl is commonly given via intramuscular injection at a dose of 15-20 mcg/kg.[26,34,41,49] Direct fetal analgesia may also help to prevent bradycardia resulting from pain.[50]

Fetal monitoring

Fetal wellbeing is primarily evaluated by sonographic monitoring of fetal heart rate and umbilical artery blood flow.[11] In the fetus, heart rate is crucial to cardiac output, given relatively poor myocardial compliance and minimal response to changes in preload.[51] Absent or reversed umbilical artery diastolic blood flow is associated with increased perinatal morbidity and mortality.[52] Intraoperative fetal echocardiography can also be used to monitor ventricular function, valve competence, ductal patency and amniotic fluid index.[18,25] At our institution, this role is performed by a neonatologist.

Common causes of fetal bradycardia include mechanical compression or kinking of the umbilical cord, uterine contractions, placental separation, maternal hypotension, umbilical artery vasospasm or hypoxaemia.[5] Less common causes include fetal hypovolaemia, hypothermia and anaemia.[5] Fetal cardiac events may be reduced when volatiles are supplemented with IV anaesthesia.[29]

To manage fetal bradycardia, it is essential to ensure adequate uterine blood flow, assess the uteroplacental interface, and relieve umbilical or placental compression. Fetal intramuscular atropine (20 mcg/kg) may be administered, with some fetal therapy centers using it prophylactically.[11,34] The anaesthetist should increase maternal inspired oxygen, stabilise maternal haemodynamics, address aortocaval compression, and administer additional tocolytics or increase volatile agents if contractions occur. The surgeon should address mechanical cord compression through fetal repositioning and increasing amniotic fluid volume.[5]

Other considerations for fetal monitoring include blood loss and temperature. Maternal and fetal bleeding can be challenging to quantify but may be aided by laboratory testing. Fetal transfusion is possible via the umbilical vein. With an inability to thermoregulate, vasoconstrict, or shiver, general anaesthesia with an open hysterotomy places the fetus at significant risk of hypothermia and subsequent bradycardia.[11] Monitoring of both maternal and amniotic fluid temperatures is recommended. Aside from standard measures to maintain maternal normothermia, warm fluids should be used for intrauterine irrigation.[11] A warm intrauterine crystalloid infusion helps prevent fetal hypothermia, provides tamponading pressure to the placental bed, prevents cord compression, and aids surgical access by elevating the fetus.[11,18] Minimising fetal exposure helps preserve both temperature and uterine volume.[25]

Table 4. Common causes of fetal bradycardia and their management

Cause	Management
Mechanical compression or kinking of umbilical cord	• Relieve mechanical compression • Fetal repositioning (surgical) • Increase amniotic fluid volume
Uterine contraction	Tocolysis • Volatiles, magnesium sulfate, GTN, remifentanil, atosiban
Maternal hypotension	• Consider vasopressors, inotropes or fluid (guided by cardiac output monitoring) • Review depth of anaesthesia • Relieve aortocaval compression
Maternal hypoxaemia	• Increase maternal FiO2 • Optimise ventilation
Umbilical artery vasospasm	Warm intrauterine irrigation
If initial management fails, consider fetal resuscitation with intramuscular atropine or adrenaline, intravenous fluid or blood products, or chest compressions *If bradycardia persists, consider delivery and neonatal resuscitation if indicated*	

Optimising surgical conditions

Fetal immobility is desirable for optimal surgical conditions. Volatile administration, placental transfer of maternal analgesia, and direct fetal analgesia all promote fetal immobility. It is common to administer fetal muscle relaxant (rocuronium, vecuronium or pancuronium) along with fentanyl and atropine in a single IM injection.[5,11,16,25,26,41]

Fetal resuscitation

Cardiovascular compromise during open fetal surgery is common. Rychik et al report a 7 per cent incidence of serious cardiovascular events and a need for fetal resuscitation with external cardiac compressions in 4 per cent of cases.[53] In-utero resuscitation or emergency delivery may be required to improve fetal, neonatal and maternal outcomes,[25] and neonatal specialists should be immediately available. Atropine (20 mcg/kg), adrenaline (10 mcg/kg), and crystalloids (10 ml/kg) in a sterile preparation should be available for surgical administration to the fetus.[11] Blood should be immediately available for fetal transfusion in the event of significant bleeding (type O-negative, irradiated, leucocyte-depleted, cytomegalovirus-negative and cross-matched against the mother).[11] In a global survey study of twenty-eight fetal surgical centres, there was no standard protocol for fetal resuscitation or subsequent neonatal resuscitation when confronted with an imminent delivery.[21]

POSTOPERATIVE CONSIDERATIONS

Key postoperative considerations are outlined in Table 5.

Table 5. Postoperative considerations after open myelomeningocele repair

Postoperative considerations	
Tocolysis	Magnesium infusion PR indomethacin
Maternal analgesia	Thoracic epidural (continuous infusion for 2 days postoperatively) Regular and PRN oral analgesia
Maternal monitoring	Premature labour Pulmonary oedema – minimal IV fluids Infection
Fetal monitoring	One-to-one midwifery care in birth suite for 24-48 hours Fetal heart rate monitoring as directed by MFM Obstetric ultrasound within 48 hours

Tocolysis

Since uterine instrumentation can precipitate contractions and preterm labour, it is imperative to monitor uterine activity and provide tocolysis postoperatively. In more than a third of cases, open fetal surgery resulted in uterine thinning at the surgical site.[12] Due to risks of placental abruption, uterine dehiscence and uterine rupture, active labour should be avoided, and all pregnancies should be delivered via caesarean section.[12] Magnesium remains a mainstay of tocolysis, beginning in the intraoperative period and typically continued as an infusion for 24-48 hours.[5, 25] Other agents utilised include nifedipine and indomethacin, the latter requiring fetal monitoring for premature closure of the ductus arteriosus.[25] Despite such efforts, there is a significant risk of premature labour, with MOMS reporting an average gestational age of 34 weeks and a 13 per cent incidence of births occurring before 30 weeks following open fetal surgery.[12]

Analgesia

Postoperative analgesia is principally managed with epidural and oral analgesia. Although epidurals are not universally used,[24] their use is well supported for open procedures.[5,25] Patient-controlled analgesia (PCA) with IV opioids may be used as an adjunct. Opioids improve patient analgesia and can decrease the risk of preterm labour,[54] but may reduce fetal heart rate variability,[55] raising concerns for fetal wellbeing.

Pulmonary oedema

The MOMS reported a 6 per cent rate of maternal pulmonary oedema following open myelomeningocele repair.[12] Pulmonary oedema is postulated to result from increased vascular permeability in the setting of gestational physiologic changes, tocolytic medications and liberal fluid therapy.[56] The use of GTN for tocolysis has been associated with more severe cases, possibly due to an immune complex-mediated reaction.[40] However, a more recent retrospective study[34] did not identify any significant association with fluid administration, crystalloid volume, colloid volume, sevoflurane dose, GTN dose or number of postoperative tocolytic drugs, and evidence does not support restrictive fluid regimes.[11] Most cases are not severe and can be treated with simple measures such as oxygen, positioning and diuresis. Patients remain closely monitored in our birth suite for 48 hours postoperatively.

Fetal monitoring

Fetal wellbeing is routinely monitored for 48-72 hours postoperatively. Aside from preterm labour, fetal risks include heart failure, intracranial haemorrhage and fetal demise.[5] A predetermined plan for delivery, resuscitation and/or palliation should be established in the event of fetal distress, carefully considering the medical circumstances, gestational age and the wishes of the parents.[21] There is a lack of consensus among fetal therapy centres regarding the gestational age at which neonatal resuscitation may be considered in the event of emergent delivery.[21] Due to the need for regular postoperative fetal monitoring, patients must remain within close proximity of their fetal therapy centre until delivery.

FUTURE DIRECTIONS

As surgical techniques evolve, so too must the complementary anaesthetic approach. In recent years, there has been an increased uptake of fetoscopic approaches to myelomeningocele repair.[34] Although technically challenging, the use of fetoscopy rather than hysterotomy in open fetal surgery reduces uterine stimulation and, therefore, requires less tocolysis. Such an approach allows for reduced volatile requirements, with less haemodynamic instability and subsequent need for vasoactive support.[34] Total percutaneous fetoscopic repairs have obvious maternal advantages in minimising pain and improving postoperative recovery. The approach may also allow for subsequent vaginal delivery, given open repairs carry similar risks of uterine rupture to classical caesareans. However, future fertility and abnormal placentation rates remain unclear.[57]

Anaesthetic techniques may also change as new drugs become available. Atosiban, an oxytocin receptor antagonist, has been demonstrated to be safer than magnesium sulfate for tocolysis during open fetal surgery.[58] It provides comparable uterine relaxation with fewer maternal complications, although it is yet to be made available for routine clinical use in Australia.

The effects of anaesthesia on fetal neurodevelopment remain of interest. Reassuringly, follow-up of the initial MOMS patients did not show impaired cognitive outcomes compared to postnatal repair. Furthermore, the subset of patients who did not require shunts or developed hydrocephalus may have improved cognitive outcomes.[14] However, ongoing research is needed to tailor anaesthesia to reduce long-term risks.

CONCLUSION

Anaesthesia is integral to the highly specialised multidisciplinary care required for fetal myelomeningocele repair. Knowledge of fetal and maternal physiology allows anaesthetists to play a pivotal role throughout the perioperative period. Given low case volumes and the complexity of research in the area, care must be based on established practices and continually refined with emerging data. While confined to specialised centres, global collaboration will help to inform evidence-based protocols and improve the delivery of care for patients undergoing fetal surgery.

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