



Anaesthesia for non-obstetric surgery during pregnancy

B.D. Brakke and H.P. Sviggum*

Mayo Clinic, Rochester, MN, USA

*Corresponding author: sviggum.hans@mayo.edu

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Learning objectives

By reading this article, you should be able to:

- Discuss the impact of pregnancy on perioperative care.
- Counsel a pregnant patient on maternal and fetal risks, benefits and outcomes of non-obstetric surgery during pregnancy.
- Formulate a plan for anaesthesia for the pregnant patient undergoing non-obstetric surgery.

Approximately 1% of pregnant women in the UK and USA will undergo surgical procedures unrelated to pregnancy.¹ For many clinicians, providing anaesthesia to a pregnant woman can be a worrisome and stressful event. This article reviews management strategies and addresses many of the concerns regarding the provision of an anaesthetic for a pregnant patient undergoing non-obstetric surgery.

The most common indications for non-obstetric surgery during pregnancy include appendicitis, cholecystitis, trauma, malignancy and gynaecological disease. However, almost all types of non-elective surgeries have been performed in

Benjamin Brakke DO is a Mayo Clinic scholar and is completing a fellowship in critical care at Mayo Clinic. He previously completed a fellowship in obstetric anaesthesia, also at Mayo Clinic, Rochester MN.

Hans Sviggum MD is a consultant in anesthesiology and perioperative medicine at Mayo Clinic and associate professor of anesthesiology at the Mayo Clinic College of Medicine and Science. He is the director of obstetric anesthesiology at Mayo Clinic. His major clinical and research interests are labour analgesic techniques and perioperative nerve injury.

Key points

- No anaesthetic agent in current use is teratogenic at clinical doses and concentrations.
- Maintaining normal maternal oxygenation, acid–base status and uteroplacental perfusion will help optimise fetal outcomes.
- Maternal outcomes after non-obstetric surgery during pregnancy are comparable with those of non-pregnant patients undergoing similar abdominal and pelvic procedures.
- Non-obstetric surgery in pregnancy requires a multidisciplinary approach involving anaesthesia, obstetric, surgical and neonatology teams.

pregnant patients. Although perioperative maternal outcomes for general abdominopelvic and trauma surgery are similar to those of non-pregnant women undergoing a similar procedure, there are some possible risks to the fetus. Those include untoward effects from the disease process itself, intraoperative disturbances in uteroplacental blood flow or fetal oxygenation, fetal loss or preterm delivery and neurodevelopmental effects of anaesthetic agents on the developing fetal brain.^{1–3} Fortunately, all modern anaesthetic agents used at clinical doses have no reported teratogenic effects. The greatest risk to the fetus is any process that causes maternal hypoxia or hypotension. Ultimately, what is good for the mother's health tends also to be good for the health of the fetus.

Effects of anaesthesia and surgery

In general, maternal outcomes after non-obstetric surgery are good. The most commonly reported complications include reoperation (3.6%), infection (2.0%), wound morbidity (1.4%), prolonged mechanical ventilation or reintubation (2.0%), venous thromboembolism (0.5%) and death (0.25%).⁴ A

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propensity-matched retrospective cohort study using data from the American College of Surgeons National Surgical Quality Improvement Program reported that 30-day mortality rates (0.4% in pregnant women compared with 0.3% in non-pregnant women) and the rate of overall morbidity (6.6% in pregnant women compared with 7.4% in non-pregnant women) were not different in pregnant and non-pregnant women undergoing the same surgery.² Based on these findings and those of other studies, general abdominopelvic surgery appears to be as safe for pregnant as for non-pregnant women.

The increased risk of adverse obstetric events resulting from non-obstetric surgery during pregnancy is low, but definitive conclusions are elusive, with most data generated by retrospective cohort studies. At baseline, early pregnancy loss occurs in approximately 10% of all recognised pregnancies, whereas pregnancy loss in the second trimester occurs in <1% of patients.⁵ A systematic review, including data from more than 12,000 surgeries during pregnancy, reported a 10.5% incidence of first-trimester pregnancy loss and an overall miscarriage rate of 5.8%.³ A study of patients undergoing abdominal surgery during pregnancy reported a three-fold increased risk of miscarriage compared with women not undergoing surgery.⁶ Although pregnant patients undergoing non-obstetric surgery should be counselled about the risk for pregnancy loss, it is ultimately unclear whether the increased risk results from the underlying maternal condition (e.g. infection), surgery or anaesthesia or other maternal factors.¹ It is important to note that urgent procedures should not be delayed because a delay in surgical treatment can lead to more maternal and fetal complications.⁷ Although the risk of pregnancy loss is most salient early in pregnancy, preterm delivery is higher in patients undergoing non-obstetric surgery during the third trimester compared with controls by almost 50%.^{1,8} In addition, the risk of Caesarean delivery or having a low-birth-weight infant is also increased in pregnant patients who undergo non-obstetric surgery.¹

A substantial worry for both providers and patients is the potential teratogenic effect of anaesthetic agents. Approximately 50 yrs ago, it was reported that there was an association between cleft lip in children and maternal first-trimester diazepam ingestion.⁹ This association was later proved to be false.¹⁰ However, it still causes concern amongst anaesthetists. In animal studies, the teratogenic effect of anaesthetic agents appears to depend on the dose/concentration given, the length of exposure, the stage of fetal development and individual species susceptibility. Fortunately, multiple large retrospective studies in humans reported no increased risk of congenital defects in infants born to mothers who had surgery and anaesthesia during pregnancy compared with non-exposed mothers. There is no evidence of teratogenic risk for any currently used anaesthetic agents for non-obstetric surgery at clinical doses and concentrations, even when used in early pregnancy.^{3,11,12}

In 2016, the US Food and Drug Administration issued a drug safety warning regarding general anaesthesia during pregnancy. The warning relates to concern of the potential effect on the developing brain and subsequent learning and behaviour traits of a child as a result of exposure to anaesthetic agents. Neurodevelopmental processes are highly sensitive to external influences, and it is clear from preclinical studies that exposure to anaesthetic agents *in utero* can alter neuroapoptosis and synaptogenesis.¹³ Although several studies on anaesthetic exposure in young children were reassuring and

suggested that an isolated anaesthetic of short duration does not lead to subsequent detriments in learning or intelligence, few clinical studies have evaluated children exposed to anaesthetic agents during maternal non-obstetric surgery during pregnancy.^{14,15} One small study reported that children exposed to general anaesthesia *in utero* displayed increased externalising behaviour later in life with no difference in intelligence when compared with non-exposed children.¹⁶ A recent study reported no change in fetal neurodevelopmental outcomes with exposure to anaesthesia for non-obstetric surgery during pregnancy.¹² The effect of anaesthetic agents on the developing fetal brain is an area of ongoing research, but there is currently insufficient evidence to recommend a specific general anaesthetic technique or change standard practice to reduce the risk of fetal neurotoxicity. Using regional anaesthesia when feasible and limiting the overall duration of anaesthetic exposure may limit any potential adverse effects on neurodevelopment.

Planning for non-obstetric surgery in pregnancy

A pregnant woman should never be denied surgery that is medically indicated or have that surgery delayed.¹¹ However, because of the potential for adverse events, including spontaneous abortion, preterm labour or delivery and fetal drug exposure, elective surgery should be delayed until after delivery. 'Elective' surgeries are those that can be delayed until after delivery with little or no untoward effects on the mother. To a greater degree, most indicated surgeries should be performed during pregnancy, given the reassuring maternal and fetal outcomes along with the potentially negative impact if indicated surgeries are not performed. Non-obstetric surgery has been safely and successfully performed at all gestational ages. Historically, the second trimester has been considered the opportune time to perform surgery because the risk of spontaneous abortion is lower than in the first trimester, and the incidence of preterm labour and delivery is lower than in the third trimester. Laparoscopic surgery can be performed safely during all trimesters of pregnancy, and pregnant patients experience the same benefits of laparoscopic surgery as non-pregnant patients. Pneumoperitoneum pressures should be kept at 15 mmHg or less, and consideration should be given to open scalpel instrument insertion in the third trimester to prevent potential uterine puncture.¹⁷ The specific surgical approach should be based largely on the surgeon's preference with a consideration of the risks and benefits of each approach.

In addition to standard anaesthetic assessment before surgery, patients should be reassured that treatment with a medically indicated surgery is the best course of action for themselves and their child, as patients are often concerned about the potential effects of surgery and anaesthesia and may be hesitant to undergo the procedure.¹¹ Additional laboratory testing or other investigations beyond those typical for the planned procedure are not indicated. Special attention should be given to examination of the airway, as pregnant patients have significantly higher incidences of both difficult and failed intubation than non-pregnant patients.¹⁸ In coordination with the obstetric care provider, a plan for fetal heart rate (FHR) monitoring and potential intraoperative Caesarean delivery should be discussed. Neonatal consultation is warranted to discuss newborn care if intraoperative Caesarean delivery was to possibly occur.

Preparation for anaesthesia

Traditionally, pregnant patients have been considered at increased risk of pulmonary aspiration because of increased intragastric pressures from the gravid uterus and decreased lower oesophageal sphincter tone from elevated progesterone concentrations. However, multiple large studies have failed to identify pregnancy as a risk factor for aspiration.¹⁹ Similarly, the Serious Complications Repository (SCORE) project found no cases of aspiration in 96,127 Caesarean deliveries, of which 5,332 were performed under general anaesthesia.²⁰ In a retrospective review of 51,086 first-trimester and 11,039 second-trimester pregnant patients undergoing deep sedation with propofol, there were no cases of pulmonary aspiration.²¹ Furthermore, the most recent closed claims analysis reported only four out of 115 aspiration events in pregnant patients, with three of those occurring during Caesarean delivery.²² Taken together, these data suggest that the risk of aspiration in pregnant patients without obesity and who have met fasting guidelines is extremely low and is not likely to be different from non-pregnant patients. The decision to give preoperative aspiration prophylaxis, such as a non-particulate antacid, a H₂ receptor antagonist or metoclopramide, should be individualised based on other risk factors and current symptoms. Standard preoperative fasting guidelines of 6–8 h for food and 2 h for clear liquids apply to pregnant patients.

Management of anaesthesia

Positioning

The goal of maternal positioning during non-obstetric surgery is to optimise surgical exposure while minimising hypotension from aortocaval compression by the gravid uterus. Beyond 18–20 weeks' gestation, patients should be positioned with a 15–30° left lateral tilt when supine to reduce aortocaval compression. In addition, for any patient with hypotension, left lateral tilt (accomplished by placing a wedge underneath the patient's right hip or by tilting the operating table) or left lateral decubitus position can substantially improve maternal haemodynamics. For some cases, this degree of lateral tilt may not be practical and may make some surgeries more difficult. Fetal acid–base status can still be preserved regardless of maternal positioning if the maternal systolic blood pressure is maintained near baseline.²³

Monitoring

Maternal monitors should be instituted as per the ASA standard for basic monitoring with no additional monitors required because of pregnancy. Advanced monitoring should be determined by the type of surgery and patient comorbidities. At a minimum, every pregnant patient should have preoperative and postoperative documentation of FHR (Table 1).¹¹ Additionally, patients of viable gestational age should be monitored for contractions along with electronic FHR monitoring before and after the procedure. The decision to use intraoperative FHR monitoring should be taken by the multidisciplinary team, based on gestational age, type of surgery, available resources and risk of fetal distress during surgery from fetal or maternal comorbidities. Table 1 highlights additional considerations for intraoperative FHR monitoring. All anaesthetic agents cross the placenta and can reduce FHR variability and lower baseline FHR. However, worsening FHR tracing can indicate uterine hypoperfusion. Therefore, the most useful purpose for monitoring FHR intraoperatively is to identify any reversible factors that might adversely affect the fetus and are not identified by maternal monitoring alone. However, there is no evidence that intraoperative FHR monitoring improves outcomes.²⁴

Choice of anaesthetic technique

General, regional, neuraxial and sedation techniques have all been used successfully for non-obstetric surgery. When formulating a plan for anaesthesia, the primary consideration is to choose a technique best suited for the patient and the procedure. Performing an unusual anaesthetic technique for the given procedure because of pregnancy can lead to unforeseen complications. Regional anaesthesia is preferred because it minimises fetal drug exposure, reduces maternal airway manipulation and can provide a degree of postoperative analgesia. Although general anaesthesia has been associated with subsequent lower fetal birth weight at delivery, no differences in maternal or fetal mortality have been noted based on type of anaesthesia used.⁸ Moderate and deep sedation have also been used safely and successfully in pregnancy.²¹ Care should be exercised to avoid oversedation and hypoventilation, which could lead to fetal hypoxia and acidosis if prolonged. Oropharyngeal and nasopharyngeal

Table 1 Types of fetal monitoring for non-obstetric surgery.¹⁴

| Type of fetal monitoring | Application |
|---|---|
| Doppler heart rate measurement before and after surgery | One-time measurement of fetal heart rate before and after surgery; most common form of fetal monitoring for preivable fetuses |
| Electronic fetal heart rate and contraction monitoring before and after surgery | Continuous monitoring of fetal heart rate and contractions for a period of time before and after surgery; most common form of fetal monitoring for a viable fetus |
| Intraoperative fetal monitoring | Continuous intraoperative monitoring: the most comprehensive form of fetal monitoring; generally reserved for viable fetuses but may be used with preivable fetuses to guide intraoperative maternal interventions that increase oxygen delivery to the fetus, such as repositioning, increasing maternal oxygen delivery or increasing maternal blood pressure; there are several considerations: <ul style="list-style-type: none"> • Intraoperative fetal monitoring should be physically possible. • A qualified individual must be present to interpret the fetal heart rate tracing continuously. • Intraoperative Caesarean delivery must be possible with an obstetric care provider readily available to intervene if indicated. • When possible, the patient has given consent for an intraoperative Caesarean delivery if indicated. |

airways should be avoided if possible, given the increased vascularity and friability of pharyngeal tissues during pregnancy.

Regional and neuraxial anaesthesia are often used to optimise postoperative analgesia and reduce fetal exposure to anaesthetic agents. Careful attention to local anaesthetic doses is important because pregnant women are theoretically at an increased risk of local anaesthetic systemic toxicity. Physiological changes of pregnancy increase the fraction of unbound local anaesthetic because of decreased α_1 acid glycoprotein concentrations, increase drug uptake because of venous engorgement and increased cardiac irritability from altered oestradiol and progesterone levels.²⁵ Hypotension from neuraxial anaesthesia may lead to reduced uteroplacental perfusion, as perfusion of the uterus is pressure dependent without autoregulation. Coloadng with i.v. fluids and giving a prophylactic vasopressor, such as phenylephrine, at the time of neuraxial block placement can significantly reduce the incidence of hypotension.

General anaesthesia is the most commonly used anaesthetic technique for non-obstetric surgery during pregnancy. Mallampati scores are usually higher in pregnancy, and the risk of failed intubation is approximately 1:533 for Caesarean delivery.²⁰ A reduction in functional residual capacity of 30–40% by the end of the second trimester combined with increased oxygen consumption contributes to more rapid oxygen desaturation during induction of anaesthesia. Effective preoxygenation with oxygen 100% is essential to achieve a safe apnoea period for intubation, ideally until the fraction of exhaled oxygen is >80%. Although propofol is the i.v. anaesthetic agent of choice, a pragmatic approach is to select induction agents and doses in the same manner as in non-pregnant patients. There is no consensus on the use of bag-mask ventilation after induction of anaesthesia. The use of rapid-sequence induction (RSI) is controversial, but many anaesthetists arbitrarily perform RSI on women beyond 15–18 weeks' gestation despite evidence that the risk of aspiration in this group is rare. Recent studies have demonstrated that the lungs of pregnant patients without obesity and are undergoing elective and urgent Caesarean delivery can be ventilated safely using a supraglottic airway device.²⁶

Neuromuscular blocking agents are large, polarised molecules that do not cross the placenta. Suxamethonium has a variable duration of action in pregnancy because of the increased volume of distribution and decreased plasma concentrations of pseudocholinesterase. However, this net prolongation of neuromuscular block is of little or no clinical significance. Currently, sugammadex is not recommended for routine reversal of neuromuscular block in pregnancy, primarily given its potential to encapsulate progesterone and potentially disrupt the integrity of the pregnancy.²⁷ There is limited evidence of maternal and fetal safety of sugammadex in patients undergoing non-obstetric surgery, as most of the current data relate to its use after Caesarean delivery. However, two recent case series of its use for fetal and non-obstetric surgery reported no pregnancy-related or fetal complications.^{28,29} Neostigmine is commonly used for reversal of neuromuscular block during pregnancy. There have been isolated reports of non-consequential fetal bradycardia when neostigmine was given in combination with glycopyrrolate, leading some to suggest atropine (which more readily crosses the placenta than glycopyrrolate) as the

anticholinergic agent of choice with neostigmine.³⁰ However, many clinicians still prefer to use neostigmine and glycopyrrolate based on clinical experience and lack of data demonstrating clinical harm with neostigmine/glycopyrrolate. Regardless of the method of neuromuscular block reversal, quantitative train-of-four monitoring should be used, ensuring a return train-of-four ratio of >90% before extubation.

Volatile inhalational and i. v. anaesthetic agents have a long history of effective and safe use for non-obstetric surgery. Inhalational agents are generally preferred for fetal surgeries and may reduce the incidence of uterine contractions and preterm labour in pregnant patients in the late second and third trimesters. All opioids have been used safely, but ketamine should be avoided, as it has been shown to increase uterine tone.

Maternal blood pressure decreases during the first trimester, reaching its lowest point near the end of the second trimester before rising again in the third trimester. As mentioned previously, blood flow to the uterus is not autoregulated and is dependent on maternal blood pressure. Although a 'safe' lower limit of maternal blood pressure is not known, maintaining a maternal blood pressure at 80–100% of baseline is generally accepted. The use of vasopressor or inotropic agents should be guided by the same indications as in non-pregnant patients. Although historically ephedrine was considered the 'gold standard' for treating hypotension during Caesarean delivery, phenylephrine has become more prevalent because of improved fetal acid–base status compared with ephedrine.³¹ Agents with beta-adrenergic stimulation can increase the FHR. Maternal arrhythmias causing haemodynamic compromise should be promptly cardioverted.

Mechanical ventilation in pregnancy generally follows the same strategies as in non-pregnant patients apart from an increased minute ventilation to accommodate the physiologic respiratory alkalosis of pregnancy. This is best accomplished by increasing the ventilatory frequency while maintaining a similar tidal volume as would be used in a non-pregnant patient. If increasing the ventilatory frequency is not sufficient to prevent hypercapnia, higher tidal volumes can be considered, understanding that plateau airway pressures up to 35 cm H₂O are usually well tolerated.³² Profound hypoventilation and maternal hypercarbia can lead to acidosis and myocardial depression in the fetus. Similarly, hyperventilation and maternal hypocarbia can cause uteroplacental vasoconstriction and fetal hypoxia.

Maintaining normothermia should be a priority, as maternal hypothermia is associated with decreased FHR, possibly from decreased uteroplacental perfusion.³³ Clinicians should consider using tools available to preserve maternal temperature, including forced air warming, fluid warming, breathing circuit heat exchanger and increasing the room temperature if necessary.

Postoperative care

Postoperative analgesia is particularly important in pregnancy, as poorly controlled pain is associated with preterm contractions and preterm labour.³⁴ Regional anaesthetic techniques, acetaminophen and local anaesthetic wound infiltration should be considered and used if appropriate. Long-term use of NSAIDs is generally avoided in pregnancy

because of increased miscarriage risk early in pregnancy and premature closure of the ductus arteriosus later in pregnancy. However, limited doses of NSAIDs can be used to control acute postoperative pain in the second and early third trimesters and do not pose a substantial risk for fetal adverse events.³⁵ Opioids have been shown to be safe when used for acute postoperative pain but should not be prescribed for longer than necessary.

The combination of the postoperative state and pregnancy places pregnant patients at a particularly high risk of deep venous thrombosis and thromboembolism. Therefore, all pregnant women should receive appropriate perioperative thromboprophylaxis, unless contraindicated.¹¹

Conclusions

In summary, non-obstetric surgery during pregnancy is common, particularly for abdominal surgery under general anaesthesia. It is of paramount importance to maintain normal maternal physiology to optimise maternal and fetal outcomes. Delaying medically necessary interventions because of pregnancy is associated with worse maternal and fetal outcomes than performing the surgical procedure during pregnancy.¹¹ Although maternal outcomes after non-obstetric surgery during pregnancy are comparable with non-pregnant patients undergoing similar procedures, there are increased risks of fetal loss, preterm delivery and low fetal birth weight. It is not known if these risks result from the disease process, surgery or anaesthesia. The strategy for caring for a pregnant patient undergoing non-obstetric surgery can be summarised by the concept that 'what is good for the mother's health also tends to be good for the health of the fetus'.

Declaration of interests

The authors declare that they have no conflicts of interest.

MCQs

The associated MCQs (to support CME/CPD activity) will be accessible at www.bjaed.org/cme/home by subscribers to *BJA Education*.

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