

Anaesthesia for non-obstetric surgery during pregnancy

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It is estimated that some 1–2% of pregnant women in developed countries undergo anaesthesia during their pregnancy for surgery unrelated to the delivery.¹ Appendicitis, ovarian torsion and trauma are among the more common indications for surgical intervention. Less commonly, cardiac and neurological procedures are undertaken during pregnancy. In order to provide safe anaesthesia for mother and fetus, it is essential to remember the physiological and pharmacological changes that characterize the three trimesters of pregnancy; these changes can pose hazards for both of them. The anaesthetist has the following goals:

- (i) optimize and maintain normal maternal physiological function;
- (ii) optimize and maintain utero-placental blood flow and oxygen delivery;
- (iii) avoid unwanted drug effects on the fetus;
- (iv) avoid stimulating the myometrium (oxytocic effects);
- (v) avoid awareness during general anaesthesia;
- (vi) use regional anaesthesia, if possible.

Pre-anaesthetic assessment

This should always involve close liaison with the obstetricians and include ultrasound assessment of the fetus when delivery is anticipated. Neonatologists will also need to be consulted. Many signs and symptoms often associated with cardiac disease, such as dyspnoea, heart murmurs and peripheral oedema are common during *normal* pregnancy. ECG changes during pregnancy include left axis deviation, premature beats and non-specific ST and T-wave changes. During radiological investigations, fetal exposure should be minimized. Results of relevant blood tests should be available and cross-matched blood must be ordered for all major surgery. Resuscitation, if required, should be vigorously performed following the usual advanced life support (ALS) or advanced trauma life support (ATLS) protocols, with the addition of left lateral tilt to avoid supine hypotension.

Pre-medication should always include aspiration prophylaxis such as ranitidine, sodium

citrate and metoclopramide. Analgesia should be prescribed where appropriate to avoid the detrimental effects of stress to the mother and fetus. Non-steroidal anti-inflammatory drugs should be avoided, because of the risk of premature closure of the ductus arteriosus. However, low dose aspirin, even when taken regularly, appears safe in this respect.

Drug considerations

Between the 15th and 56th days of gestation, the human embryo is said to be most vulnerable to the teratogenic effects of a drug.² Since 1978, most drugs used in medicine and anaesthesia have been assigned codes in the Swedish Catalogue of Registered Pharmaceutical Specialities (FASS). These codes are a guide to the appropriate choice of agents with respect to effects on the fetus, placenta and utero-placental blood flow, and the possibility of induced abortion. Studies of outcomes in large numbers of women who underwent surgery during pregnancy suggest no increase in congenital abnormalities but a greater risk of abortion, growth restriction and low birth weight. These studies concluded that problems resulted from primary disease or the surgical procedure itself rather than exposure to anaesthesia.³ Although the data available are incomplete, studies suggest that the administration of a hypnotic, opioid analgesia or sedative drug will not have deleterious effects on embryonic or fetal development. The current consensus is that benzodiazepines are not teratogenic and a single dose appears safe. Because of concerns about increased risk of cleft palate, regular use, particularly in the first trimester, should probably be avoided.⁴

Although primary effects of drugs on the fetus are often predictable (i.e. similar to those on the mother), secondary effects must also be considered, as they may have greater importance (e.g. vasoactive drugs affecting placental blood flow). Specific examples will be considered in the relevant sections of this article; however, if there is any doubt and the mother's condition warrants treatment, expert advice should be sought.

Key points

Regional anaesthesia should be used in preference to general anaesthesia where appropriate.

Optimize and maintain normal maternal physiology.

A multidisciplinary approach with senior involvement needs to be established early in the management.

If possible, surgery should be delayed until the second trimester. Elective surgery should not be performed.

Avoid all unwanted drug effects on the fetus.

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Anaesthesia and gestation

Elective surgery should not be performed at all during pregnancy, and only tubal ligation should be performed during the first 6 weeks postpartum to allow the physiological changes of pregnancy to resolve. Emergency surgery must proceed regardless of gestational age and the primary goal is to preserve the life of the mother. Where feasible, surgery is often delayed until the second trimester to reduce the risk of both teratogenicity and miscarriage, although there is no firm evidence to support this approach.

Non-viable fetus

Anaesthetic management when the fetus is dead or non-viable should follow the same principles as for the pregnant patient. If the timing of the fetal death is unknown or has occurred as a result of uterine trauma or sepsis, coagulopathy may develop and should be corrected before anaesthesia and surgery.

Anaesthesia for conception and in the first trimester

Many women receive anaesthesia and i.v. sedation for *in vitro* fertilization. The ideal anaesthetic technique should not interfere with fertilization or early embryo development and should result in minimal postoperative nausea, sedation, pain and psychomotor impairment. Most procedures can be performed with small doses of midazolam and opioids. Continuous propofol sedation and patient-controlled sedation are becoming popular. It is recommended that the use of propofol is always supervised by an anaesthetist. Some surgeons infiltrate the vaginal wall with local anaesthetic, although the benefits are controversial. Spinal anaesthesia has been used for women who want to abolish all sensation during oocyte retrieval; general anaesthesia is also used. Laparoscopy for assisted reproductive techniques may also require general anaesthesia. Nitrous oxide is avoided as animal studies provide evidence that it is a potent inhibitor of methionine synthase. However, currently, there is no evidence in human beings to suggest that this is clinically significant.

After 6–8 weeks gestation, cardiac, haemodynamic, respiratory, metabolic and pharmacological parameters are considerably altered. With the increase in minute ventilation and oxygen consumption and a decrease in oxygen reserve (decreased functional residual capacity and residual volume), pregnant women become hypoxaemic more rapidly. Supplementary oxygen must always be given during vulnerable periods to maintain oxygenation. Normal hyperventilation in pregnancy results in lowered expired CO₂ (32–34mm Hg); this should be maintained during anaesthesia.

Airway management by a face mask, a laryngeal mask or tracheal intubation can be technically difficult because of increased anteroposterior chest wall diameter, breast enlargement, laryngeal oedema and weight gain affecting the soft tissues of the neck. Nasal tube airways should be avoided in pregnancy because of increased vascularity of mucous membranes. Marked reduction of plasma cholinesterase concentrations

(30% reduction) theoretically cause succinylcholine, ester local anaesthetics and certain other drugs to have prolonged effects. However, this is counterbalanced by increased volumes for drug distribution. Therefore, it is of consequence, if at all, in the postpartum period, when enzyme activity remains depressed but the volume of distribution begins to normalize. Neuromuscular drug monitoring is recommended.

Aspiration prophylaxis is recommended from the beginning of the second trimester. Pregnancy is associated with lower anaesthetic requirements, although the mechanism for this is unknown. The minimum alveolar concentration (MAC) for inhalation anaesthetics is reduced by 30% as early as 8–12 weeks gestation. I.V. drugs that induce general anaesthesia should also be given in lower doses.

Fetal well-being should be assessed by ultrasound or Doppler before and after anaesthesia and surgery. Because of the increased risk of hypoxaemia, difficulties with intubation, acid aspiration and risks to the fetus, regional anaesthesia should be selected over general anaesthesia whenever feasible.

Anaesthesia in the second trimester

Aortocaval compression is a major hazard from 20 weeks onwards (and sometimes even earlier); this compromises uterine blood flow and, in some women, results in supine hypotension. This effect may be exacerbated by regional or general anaesthesia when normal compensatory mechanisms are attenuated or abolished. Aortocaval compression is only effectively avoided by the use of the lateral position. It can be decreased by uterine displacement through wedging or manual displacement. Venacaval compression results in distension of the epidural venous plexus, increasing the risk of intravascular injection during regional blockade. The capacity of the epidural space is reduced, which probably contributes to the enhanced spread of local anaesthetics in pregnancy.

Pregnancy is associated with a hypercoagulable state because of increased pro-coagulant factors. The incidence of thromboembolic complications is at least five times greater during pregnancy; thromboprophylaxis is essential.⁵

Anaesthesia for the third trimester

At this gestation, delivery by Caesarean section before major surgery is often recommended. Where possible, surgery should be delayed 48 h to allow steroid therapy to enhance fetal lung maturation. It may be appropriate to deliver the baby under regional anaesthesia and then convert to a general anaesthesia for the definitive surgery. Anaesthesia post delivery should be tailored to surgical requirements, with the precaution that volatile agents should be discontinued or used only in small doses (<0.5 MAC) along with oxytocics to minimize the risk of uterine atony and haemorrhage.

Surgery, stress and perhaps anaesthesia may suppress lactation, at least temporarily. Most drugs are excreted into breast milk; however, only a few are absolutely contraindicated during breast feeding (e.g. radioactive substances, ergotamine, lithium, psychotropic agents). The possible neonatal effects of other

Table 1 Physiological and anatomical changes associated with pregnancy

Systems	Anatomical	Physiological
Cardiovascular	Supine hypotensive syndrome	↑ Plasma volume 50% ↑ RCV volume 15% ↑ Cardiac output 40% (↑ HR and SV) ↓ Diastolic BP ↓ SVR 15% Basal crackles, gallop rhythm, systolic flow murmur, axis deviations, atrial and ventricular ectopics
Respiratory	↑ Thoracic circumference (5–7 cm) Elevation of diaphragm (3–5 cm) Upper airway calibre ↓ (Capillary engorgement and oedema of the airway)	↑ MV 45% (mainly ↑ tidal volume) ↓ FRC 10–25% (↓ ERV and RV) ↑ Oxygen consumption 20% ↓ P_{aCO_2} ↓ MVO_2 ↓ MAC 20–30% ↓ ED of IV sedatives and hypnotics
CNS		↑ ED of IV sedatives and hypnotics ↑ GFR (leads to ↓ plasma creatinine and urea)
Renal	Minimal renal enlargement Dilated calyceal system and ureters ↓ bladder capacity	Renal glucosuria
Gastrointestinal	Decreased lower oesophageal sphincter tone Elevation of stomach (enlarging uterus)	↑ Gastric volume and acidity Delayed gastric motility and food absorption
Coagulation		↑ Activity of coagulation factors (fibrinogen, vii, viii, ix, x); ↑ platelet count
Endocrine		Insulin sensitivity during first trimester but later ↑ insulin resistance

RCV, red cell volume; HR, heart rate; SV, stroke volume; BP, blood pressure; SVR, systemic vascular resistance; MV, minute volume; FRC, functional residual capacity; P_{aCO_2} , arterial carbon dioxide tension; MVO_2 , mixed venous oxygen; MAC, minimum alveolar concentration; ED, effective dose; GFR, glomerular filtration rate.

drugs such as opioids and sedatives should be explained to the mother. Milk may need to be expressed to maintain lactation whilst the baby is temporarily fed formula.

Fetal monitoring

Once fetal viability is assumed (24–26 weeks), the fetal heart rate (FHR) should be monitored. This may be difficult in the obese patient or during abdominal surgery. Inhalation agents typically cause a reduction in FHR variability, one of the changes indicative of fetal hypoxaemia. Intra-operative FHR monitoring requires skilled interpretation and an obstetrician with a plan of action should fetal distress be diagnosed. Uterine manipulation should be minimized in order to avoid pre-term labour. Ketamine increases uterine tone in early pregnancy and should not be used. While some advocate the prophylactic use of tocolytic agents, they are not without risk themselves and there is no proof of efficacy.

Anaesthetic technique

No studies have shown a beneficial effect on the outcome of pregnancy after regional compared with general anaesthesia. However, regional anaesthesia minimizes fetal drug exposure, airway management is simplified, blood loss may be decreased, and overall risks to the mother and fetus are less. The largest risk of regional anaesthesia is hypotension resulting from sympathetic nerve blockade, which reduces uterine blood flow and perfusion to the fetus. Attention to maternal fluid volume and blood pressure is critical. Ephedrine has traditionally been the vasopressor of choice in this situation because of its α - and β -receptor stimulating properties and lack of effect on uterine blood flow. More recent research has shown that it is more important to treat the hypotension effectively than to worry about the

choice of agent. Therefore, drugs which have previously been contraindicated (e.g. phenylephrine) are now considered safe.

General anaesthesia should only be given by a suitably trained anaesthetist experienced in administering general anaesthesia to obstetric patients.

Laparoscopic surgery

Pregnancy is no longer considered a contraindication to laparoscopic surgery. A study in Sweden involving more than 2 million deliveries, favoured laparoscopic surgery compared with an open procedure. The advantages include less exposure of the fetus to possibly toxic agents, smaller incisions, decreased pain, less need for analgesics, and more rapid recovery and mobilization.⁶ Carbon dioxide pneumoperitoneum is associated with an increased risk of hypoxaemia, hypercarbia and hypotension because of the physiological and anatomical changes of pregnancy (Table 1).

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Please see multiple choice questions 32–35.