Anaesthesia for non obstetric surgery during pregnancy

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Summary

A significant number of women undergo anesthesia and surgery during pregnancy for procedures unrelated to delivery. In order to provide safe anaesthesia for mother and fetus, it is essential for the anesthetist to have thorough understanding of the physiological and pharmacological changes that characterize the three trimesters of pregnancy. A multidisciplinary team approach involving the anesthetist, obstetrician, neonatologist and surgeon is highly recommended to ensure an adequate standard of care. Anaesthesia management, including post-operative analgesia, should be planned well to preserve the pregnancy and to ensure the safety of the mother as well as the foetus. Once fetal viability is assumed (24–26 weeks), the fetal heart rate (FHR) should be monitored. 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.

INTRODUCTION

Anaesthesia for pregnant patients may not always be only for obstetric surgeries. These patients do present with surgical illness requiring surgery under general or regional anaesthesia. With advances in fetal surgeries the number is only likely to increase in future. Incidence of non-obstetric surgery being 1-2%.[1] Surgery can be required during any stage of pregnancy depending on the urgency of the indication. In the largest single series concerning surgery and anaesthesia during pregnancy, 42% of surgery during pregnancy occurred during the first trimester, 35% during the second trimester, and 23% during the third.[2] Appendicitis, ovarian disorders (torsion or neoplasm) and trauma constitute the most common non-obstetric conditions requiring surgery during pregnancy, appendicectomy being the most common. The incidence of Appendicitis is around 1 in 1500-2000 pregnancies.[3]

Non-obstetric surgery during pregnancy presents newer challenges to the anaesthetist. The anaesthetist has to take care of two lives. The goal being safe anaesthesia for both pregnant woman and the fetus. To ensure maternal safety, the anaesthetist must have a thorough understanding of the physiological and pharmacological adaptations to pregnancy. Fetal safety requires avoidance of potentially dangerous drugs at critical times during fetal development, assurance of continuation of adequate uteroplacental perfusion, and avoidance and/or treatment of preterm labour and delivery.[4]

Principles of anaesthetic management

The anaesthetist has the following goals:[5]

(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.

Maternal safety

According to American College of Obstetricians and Gynaecologists' Committee on Obstetric Practice, regardless of trimester, pregnant woman should not be denied indicated surgery. Elective surgery should be postponed until after delivery. If possible, nonurgent surgery should be performed in the second trimester when preterm contractions and spontaneous abortion are least likely. The choice of anaesthetic technique(s), and the selection of appropriate drugs of anaesthesia should be guided by maternal indications for surgery and the location of the surgical procedure. Resuscitation, if required, should be vigorously performed following the standard advanced life support or advanced trauma life support protocols, with the addition of 150 left lateral tilt to avoid supine hypotension after 20 weeks.[6]

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Rapid-sequence intravenous induction and intubation, with effective cricoid pressure, should be preceded by meticulous pre-oxygenation with 100% oxygen for 5min. Thiopentone 5mg/kg IV and Succinylcholine 1.5mg/kg iv are agents of choice. Propofol (2mg/kg iv titrated doses may be used. Rocuronium is an alternative when sugammadex is available. However, in cases of failed intubation, laryngeal mask airway has been used to ventilate successfully and safely in the reverse Trendelenburg's position for brief periods. Second generation supraglottic airway devices like Proseal LMA™ hold great potential in the management of the obstetric airway.[7] They can be used in carefully selected patients to maintain the airway. As changes in maternal position can have profound haemodynamic effects, positioning during anaesthesia should be carried out slowly.

Pregnancy is associated with an increased sensitivity to volatile anaesthetic agents, MAC values are decreased. Though all volatile agents (<1.5 mac) dilate uterine arteries and increase uterine blood flow, this is offset at higher concentrations by decreases in maternal arterial pressure and cardiac output.[8] Volatile agents also reduce uterine tone. Low concentration sevoflurane would be the preferred choice.

Ephedrine has traditionally been the vasopressor of choice for hypotension. Recent studies have challenged the superiority of ephedrine and suggest that the alpha agonists like phenylephrine are more effective in maintaining maternal blood pressure and in preventing fetal acidosis.[9]

The effects of light general anaesthesia and its associated catecholamine surge with resulting impaired uteroplacental perfusion are considerably more dangerous to foetus. Positive pressure ventilation should be used with care and end-tidal carbon dioxide levels should be maintained within the limits. Since there is a good correlation between end-tidal CO_2 ($ETCO_2$) and $PaCO_2$ in pregnancy, $ETCO_2$ can be used to guide ventilation in pregnant patients.[10] Hyperventilation should be avoided as this adversely affects uterine blood flow. Oxygenation should be optimized to ensure adequate fetal oxygen delivery. Patients should be extubated fully awake as the risk of aspiration persists until protective airway reflexes have returned.

Fetal safety

Depending on the dose administered, the timing of exposure with respect to development, and the route of administration of any drug given during pregnancy can potentially jeopardise the development of the foetus. Until date, no anaesthetic drug has been proven to be clearly hazardous to the human foetus. It may be noted that no animal model perfectly simulates human gestation and a randomised trial on pregnant patients in this regard would be definitely unethical. Hence, definitive evidence seems elusive.[11]

Teratogenicity of anaesthetic drugs

A teratogen is defined as a substance that causes an increase in the incidence of a particular defect in a foetus that cannot be attributed to chance. The teratogen must be given in a sufficient dose for a substantial period at a critical developmental point to produce the defect. When considering the possible teratogenicity of various anaesthetic agents, several important points must be kept in mind. First, the background incidence of congenital anomalies in humans is approximately 3%. Second, physiologic derangements such as hypoxaemia, hypercarbia, stress and hypotension may be teratogenic themselves. These problems can occur during anaesthesia and surgery and sometimes exist pre-operatively.

Concerns about anaesthetic effects on the developing human fetus have been considered for many years Anaesthetic drugs affect intra- and intercellular signalling and have known effects on cellular mitosis and DNA synthesis. Therefore, all anaesthetic agents can be potentially teratogenic. Despite years of animal studies and observational studies in humans, no anaesthetic drug has been shown to be clearly dangerous to the human fetus and there is no optimal anaesthetic technique. The search for a clear answer is hampered by the fact that it would not be ethical to conduct a randomized trial on pregnant patients and no animal model perfectly mimics human gestation.[12]

Nitrous Oxide inhibits methionine synthetase, an enzyme necessary for DNA synthesis. Teratogenic effects are shown in animals after administering high concentrations for prolonged periods.[10] However, such high required doses are not encountered in clinical practice. However, some recommend avoiding nitrous oxide in pregnant women.[13,14] In modern day practice, it is rarely necessary to use nitrous oxide in a pregnant patient, and we have so many alternatives for general anaesthesia.

Benzodiazepine use in pregnancy has been associated with cleft palate and cardiac anomalies. However, many recent controlled studies have countered this association.[15,16] It is usually recommended to avoid benzodiazepine use throughout gestation and most especially during the first trimester. However, it may be appropriate to provide judicious pre-operative anxiolysis so as to avoid increases in circulating catecholamine levels, which impair uteroplacental perfusion.

Most other anaesthetic medications, including barbiturates, propofol, opioids, muscle relaxants, and local anaesthetics have been widely used during pregnancy with a good safety record. Nonetheless, delicate associations cannot be ruled out.

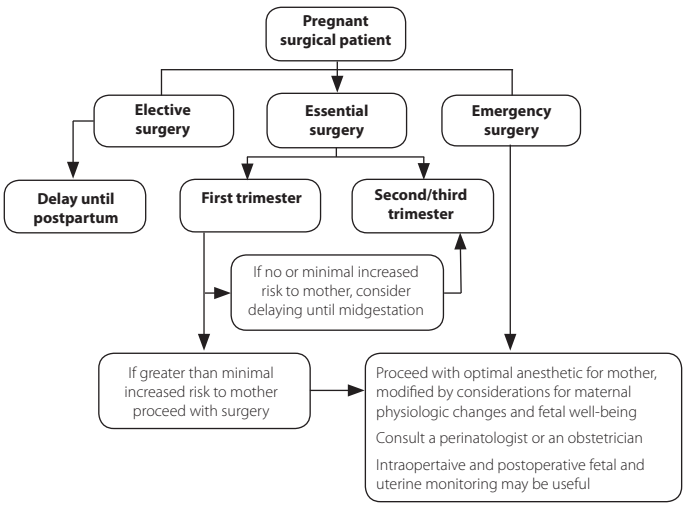

Figure 1: Decision-Making Algorithm for Non-Obstetric Surgery During Pregnancy[6]

Timing of exposure is of crucial importance. During the first 15 days of human gestation an all or nothing phenomenon occurs: the fetus is lost or the fetus is preserved fully intact. During the time of organogenesis (15-56 days) structural abnormalities may occur. After this period, functional changes can be observed, but structural abnormalities are rare.

Decision-Making Algorithm for Non-Obstetric Surgery During Pregnancy

Whenever a pregnant woman undergoes nonobstetric surgery, consultations among her obstetrical team, surgeon(s), anesthesiologist(s), and neonatologist(s) are important to coordinate management (Figure 1).

General principles of anaesthesia management

Pre-operative preparation

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.[9] 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. Pregnant patients who require surgery should be evaluated pre-operatively in the same manner as non-pregnant patients. Laboratory and other testing should be performed as indicated by the patient's comorbidities and the proposed surgery. In addition to standard pre-operative procedures, preparation of pregnant women takes into account risks of aspiration, difficult intubation, thromboembolism, and the well-being of the foetus. Standard adult fasting guidelines, i.e., 6-8 h for solid food, depending on the type of food ingested (e.g., fat content) are applicable to these patients.

Aspiration prophylaxis: The gastric emptying has recently been shown to be normal during pregnancy until the onset of labour. However, the risk of aspiration is still higher due to reduced gastric barrier pressure and lower oesophageal sphincter tone (a progesterone effect).[17] The presence of additional risk for regurgitation and aspiration, including active reflux or obesity should be surveyed. Prophylaxis against aspiration pneumonitis should be administered from 16 weeks gestation with H_2-receptor antagonists and non-particulate antacids.

Antibiotic prophylaxis: The need for antibiotic prophylaxis depends on the specific procedure. However, attention should be paid in selecting antibiotics with good safety profile in pregnancy.

Prophylactic glucocorticoids: Administration of a course of antenatal glucocorticoids 24-48hrs before surgery between 24 and 34 weeks of gestation can reduce perinatal morbidity/mortality if preterm birth occurs. Despite the potential benefits to the foetus, however, antenatal glucocorticoids are best avoided in the setting of systemic infection (such as sepsis or a ruptured appendix), because they may impair the ability of the maternal immune system to contain the infection.

Thromboprophylaxis: Pregnancy is a hypercoagulable state. The 2012 American College of Chest Physicians clinical practice guideline on prevention and treatment of thrombosis recommends mechanical or pharmacologic thromboprophylaxis for all pregnant patients undergoing surgery.

Prophylactic tocolytics: There is no proven benefit to routine administration of prophylactic perioperative tocolytic therapy. Minimising uterine manipulation may reduce the risk of development of uterine contractions and preterm labour. Tocolytics are indicated for the treatment of preterm labour until resolution of the underlying, self-limited condition that may have caused the contractions.

Conduct of Anaesthesia

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. Regardless of the anaesthetic technique, steps to avoid hypoxemia, hypotension, acidosis, and hyperventilation are the most critical elements of anaesthetic management.

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 CO_2 (32–34mm Hg); this should be maintained during anaesthesia.

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 150 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.[18]

During third trimester, delivery by caesarean section before major surgery is often recommended. Where possible, surgery should be delayed 48hr 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.

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 to avoid preterm 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.

The ACOG states, "although there are no data to support specific recommendations regarding nonobstetric surgery and anaesthesia in pregnancy, it is important for non-obstetric physicians to obtain obstetric consultation before performing non-obstetric surgery. The decision to use fetal monitoring should be individualized and each case warrants a team approach for optimal safety of the woman and her baby.[19]

General guidelines for fetal monitoring include the following:[20]

If the fetus is considered previable, it is generally sufficient to ascertain the fetal heart rate by Doppler before and after the procedure.

At a minimum, if the fetus is considered to be viable, simultaneous electronic fetal heart rate and contraction monitoring should be performed before and after the procedure to assess fetal well-being and the absence of contractions.

Intraoperative electronic fetal monitoring may be appropriate when all of the following apply:

- The fetus is viable.
- It is physically possible to perform intraoperative electronic fetal monitoring.
- A health care provider with obstetric surgery privileges is available and willing to intervene during the surgical procedure for fetal indications.
- When possible, the woman has given informed consent to emergency caesarean delivery.
- The nature of the planned surgery will allow the safe interruption or alteration of the procedure to provide access to perform emergency delivery.

Monitoring for uterine contractions

When external tocodynamometer can be placed outside of the surgical field, uterine contractions may be monitored intraoperatively. If uterine contractions are detected, maternal haemodynamics should be improved by giving more intravenous fluids and also consider tocolytic treatment in consultation with the perinatologist/obstetrician. Tocometry during post-operative period is useful as post-operative analgesia may mask awareness of mild early contractions and delay tocolysis.

Recovery from anaesthesia

Recovery from anaesthesia requires close monitoring, particularly of the airway and respiratory system, because most severe anaesthetic complications due to hypoventilation or airway obstruction occur during emergence, extubation, or recovery.

Post-operative analgesia

Provision of adequate analgesia is important in the post-operative period as well, since the pain has been shown to increase the risk of premature labour. Regional nerve or plexus blockade or epidural analgesia can provide excellent post-operative analgesia and reduce the risk of opioid-induced hypoventilation when compared with intravenous opioids. Ultrasound guided Transverse abdominis plane (TAP) block is an alternative to epidural analgesia. Though TAP block blocks only somatic component of pain while epidural blocks both somatic and visceral component, both provide adequate analgesia for abdominal studies. A randomised control study found no difference in pain scores, pain scores over time and opioid requirements between continuous TAP block and epidural analgesia.[21] Opioids can be used, as needed, to control post-operative pain. Paracetamol is the analgesic of choice for the treatment of mild to moderate pain during any stage of pregnancy. NSAIDs should be avoided, especially after 32 weeks of gestation, because they may cause premature closure of the foetal ductus arteriosus (if given for more than 48hrs). They are also associated with oligohydramnios with reduced foetal renal function. NSAIDs can also inhibit uterine contraction.

Specific Procedures

Laparoscopy

Pregnancy is no longer considered a contraindication to laparoscopic surgery. Indications for laparoscopic treatment of acute abdominal processes are the same as for nonpregnant patients. Laparoscopy can be safely performed during any trimester of pregnancy. 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.[22] Carbon dioxide pneumoperitoneum is associated with an increased risk of hypoxaemia, hypercarbia and hypotension because of the physiological and anatomical changes of pregnancy. Society of American Gastrointestinal Endoscopic Surgeons issued following guidelines.[23] Fetal and uterine status should be monitored and also end-tidal PCO_2 and maternal arterial blood gases. An open technique should be used to enter the abdomen. Aortocaval compression should be avoided. Low pneumoperitoneum pressures (between 10 and 15mmHg) should be used. Tocolytic agents should not be used prophylactically but should be considered when evidence of preterm labor is present.

Cardiac Surgery

The cardiovascular changes of pregnancy include a 30-50% increase in blood volume and cardiac output. Although pregnant patients with heart disease are usually managed with medical therapy, those with severe decompensation and surgically correctable lesions might

come to surgery, in particular those with severe mitral or aortic valvular obstruction.[24,25] Percutaneous balloon valvuloplasty seems to be a better alternative than surgical repair and is associated with a significant reduction in fetal and neonatal mortality. The use of cardiopulmonary bypass increases perioperative risk, particularly for the fetus. Factors related to cardiopulmonary bypass that can adversely affect fetal oxygenation include non-pulsatile perfusion, inadequate perfusion pressures, inadequate pump flow, embolic phenomena to the uteroplacental bed, and the release of renin and catecholamines. The use of intraoperative fetal monitoring can decrease the high fetal mortality rate. During cardiopulmonary bypass, a high pump flow (>2.5 litre min^{-1} m^{-2}) and perfusion pressure (>70mmHg) are recommended to maintain uteroplacental blood flow.[15] It is recommended that the maternal haematocrit be maintained >28% to optimize oxygen-carrying capacity.[26,27]

Neurosurgery

Haemorrhage from intracranial saccular aneurysm or arteriovenous malformation is unfortunately not uncommon during pregnancy. The risk of intracranial haemorrhage is increased by hypertensive conditions of pregnancy and their associated risk factors. The usual neurosurgical anaesthetic treatment of these patients can include controlled hypotension, hypothermia, hyperventilation, and diuresis, which must be undertaken carefully in the pregnant patient. Controlled hypotension can be induced with high-dose volatile anaesthetic, sodium nitroprusside, or nitroglycerin. Each carries its own potential hazards in addition to reduction in uteroplacental blood flow. All of these drugs cross the placenta and can induce hypotension in the fetus.[28] When induced hypotension is deemed necessary, fetal heart rate monitoring should be used and the period of hypotension. Hyperventilation is commonly used in neuroanaesthesia to reduce and cerebral blood flow. Extreme hyperventilation ($PaCO_2$ <3.3kPa) can cause uterine artery vasoconstriction and leftward shift of the maternal oxyhaemoglobin dissociation curve. Fetal heart rate monitoring should alert the anaesthesiologist to compromises in fetal condition and adjustments to maternal ventilation should be made accordingly. Diuresis is often accomplished with osmotic agents or loop diuretics to shrink the brain both intraoperatively and after operation. These can cause significant negative fluid shifts for the fetus. However, in individual case reports, mannitol in small doses of 0.25–0.5mg kg^{-1} has been used without ill effect to the fetus and appears safe if required.[29] A loop diuretic provides an alternative but should also be used cautiously with fetal monitoring and only if necessary.

Fetal Surgeries

Surgery to the fetus while it is still in utero is used to treat an increasing number of lethal and non-lethal conditions. The problems of preterm labour and premature rupture of membranes associated with open surgery have led to the development of minimal access surgical techniques. Although fetal surgery is a new and fast-moving frontier of medicine, it is not one that all obstetric anaesthetists will encounter. The first successful human fetal operation was performed in 1983, but it is still only carried out in a limited number of specialist tertiary centres. There are basically three different type of surgeries – Minimally invasive, Midgestation Open procedures or EXIT (Ex utero intrapartum) procedures. The broad challenges presented to the anaesthetist are: techniques used to prevent preterm labour, maintenance of maternal homeostasis in the face of tocolytic techniques, maintenance of fetal homeostasis and provision of fetal analgesia during surgery.[30]

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