

Why is it so anxiety-provoking to find that your otherwise routine surgical case also happens to be pregnant? About 2% of parturients will have surgery during their pregnancy, involving over 75,000 anesthetics per year. This number is increasing, largely due to laparoscopic procedures. Most surgeries are performed to treat conditions common to this age group: trauma, ovarian cysts, appendicitis, cholelithiasis, breast mass requiring biopsy, and cervical incompetence. However major procedures such as craniotomy, cardiopulmonary bypass, and liver transplantation may also be necessary in the pregnant patient, usually with good outcomes for mother and fetus. Despite the overall good outcomes, there is a strong aversion among medical and non-medical people to drugs being used or procedures being performed during pregnancy. For example, during congressional testimony on late-term abortions the erroneous statement was made that “The fetus usually dies from the anesthesia administered to the mother before the procedure begins.” Naturally, with misinformation like this available, a pregnant patient requiring surgery is likely to present with extreme anxiety. How do you counsel a pregnant patient having surgery? What can you tell her about the risks associated with her anesthetic?

RISK ASSESSMENT

Anesthetic management now involves two patients and physiology specific to pregnancy. Thus several unique concerns are addressed when creating an anesthetic plan.

Alterations in maternal physiology involve every organ system, but those most important to anesthetic management include the following:

1. *Respiratory* - higher oxygen consumption, lower functional residual capacity, lower pCO₂ due to elevated minute ventilation, greater likelihood of difficult intubations, increased mucosal vascularity
2. *Cardiovascular* - increased blood volume and cardiac output, dilutional anemia, aortocaval compression when supine, decreased vascular responsiveness but an increase in baroreceptor responsiveness
3. *Gastrointestinal* - gastric volume, pH, and emptying *may* not be altered during pregnancy, but gastro-esophageal sphincter tone is usually reduced
4. *Central nervous system* - local anesthetic requirements and MAC for inhalational agents are both decreased during pregnancy.

Teratogenic effects of anesthetics are probably minimal to nonexistent and have never been conclusively demonstrated. The drugs of most concern are nitrous oxide and the benzodiazepines. In animal studies, nitrous oxide may vasoconstrict uterine vessels and decrease uterine blood flow if not combined with a halogenated (sympatholytic) agent. No adverse effect of nitrous oxide has been demonstrated in human pregnancy. The benzodiazepines were anecdotally associated with oral cleft anomalies, but case-control and prospective studies failed to find any relationship with diazepam use during pregnancy. The inhalational agents, narcotics, intravenous agents, and local anesthetics have a long history of safety when used during pregnancy. A recent meta-analysis of studies on anesthetic exposure in the workplace concluded that a slight increase in miscarriage is the only potential obstetric problem for OR personnel, and even that risk is lower than for smokers or personnel working in radiology.

Maintenance of uterine perfusion and maternal oxygenation preserve fetal oxygenation. These are key to any anesthetic during pregnancy. Be aware of effects your interventions may have on maternal cardiac output, oxygen delivery, and uterine blood flow. Above all, avoid maternal hypoxia and hypotension!

Prevention and treatment of preterm labor is the most difficult problem to surmount perioperatively, and preterm delivery is the most common cause of fetal loss. It is probably not related to anesthetic management, but to the underlying disease and the surgery itself. Unfortunately there are no reliable therapies to prevent or treat preterm labor.

ANESTHETIC MANAGEMENT

Preoperative assessment should include: pregnancy testing if the diagnosis is unsure or if the patient requests it, considering delay to the second trimester, counseling the patient on anesthetic risks (or lack thereof) to the fetus and pregnancy, and educating her on symptoms of preterm labor and the need for left uterine displacement. Mandatory pregnancy testing is a controversial issue. Date of her last menstrual period should be documented on the anesthetic record if she is between the ages of 12 and 50, and testing offered if more than 3 weeks has elapsed or if the patient requests testing. If surgery can be delayed until the second trimester, risk of teratogenicity and spontaneous miscarriage are less and preterm labor is not as common as it may be during the third trimester.

Preoperative medications to allay anxiety or pain are appropriate, since elevated maternal catecholamines may decrease uterine blood flow. Consider aspiration prophylaxis with some combination of an antacid, metoclopramide, or H₂-receptor antagonist. Discuss perioperative tocolysis with her obstetrician. Indomethacin (oral or suppository) and magnesium sulfate (infusion) are the most common tocolytics used. Indomethacin has few anesthetic implications, but magnesium can potentiate muscle relaxants and make hypotension more difficult to treat during blood loss or volume shifts.

Intraoperatively there is no evidence that any anesthetic technique is better than another as long as maternal oxygenation and perfusion are maintained. A recent review of 49,000 consecutive pregnancies found that 0.14% required surgery during pregnancy. The authors were unable to show that type of surgery, type of anesthetic, trimester in which surgery occurred, length of surgery, estimated surgical blood loss, or length of anesthesia affected pregnancy outcome. Monitoring should include blood pressure, oxygenation, ventilation (end-tidal CO₂), and temperature. Remember pCO₂ is about 10 torr lower during pregnancy. Blood glucose should be checked if the procedure is long.

If it will not interfere with the surgical field, intermittent or continuous fetal monitoring should be performed after ~20-24 weeks to ensure the intrauterine environment is optimized. This should be approached as a *medical* issue, not a *medicolegal* one! Loss of beat-to-beat variability is normal after anesthetic medications, but decelerations are not. They may indicate the need to increase maternal oxygenation, raise her blood pressure, increase uterine displacement, change the site of surgical retraction, or begin tocolytics. Fetal monitoring can help assess the adequacy of perfusion during induced hypotension, cardiopulmonary bypass, or procedures involving large volume shifts. If the mother is awake during a regional anesthetic, it can be very reassuring to her to hear fetal heart tones during the procedure, even if measured intermittently. However, monitoring may be impractical in urgent situations or during abdominal surgery. Monitoring has not been proven to improve fetal outcome and may require personnel with L&D expertise. Misinterpretations could also lead to unsafe interventions.

General anesthesia should include full preoxygenation and denitrogenation, rapid sequence induction with cricoid pressure, a high concentration of oxygen, and slow reversal of relaxants to prevent acute increases in acetylcholine that might induce uterine contractions. Inhalational agents should be kept below 2.0 MAC to prevent decreased maternal cardiac output. During the first trimester, ketamine at doses > 2 mg/kg may cause uterine hypertonus. Nitrous oxide and propofol may be used at the anesthesiologist's discretion. Propofol has recently been shown to reduce oxytocin-induced contractions of uterine smooth muscle. Unlike most other agents, early pregnancy does not decrease the concentration of propofol required for loss of consciousness. Keep in mind the pregnant airway is more edematous and vascular, and visualization may be more difficult during laryngoscopy.

Regional techniques have the advantage of minimizing drug exposure, thus allaying concerns about teratogenicity during the first trimester and minimizing changes in FHR variability on the fetal monitor later in gestation. Prevent hypotension with adequate preload and uterine displacement, and treat aggressively with pressors if needed. Decrease the neuraxial dose of local anesthetic by about one-third from that used in nonpregnant patients. Regional anesthetics provide excellent postoperative pain control, reducing maternal sedation so she can report symptoms of preterm labor and also maintaining FHR variability on the monitor.

Postoperatively, continue monitoring fetal heart rate and uterine activity. Preterm labor must be treated early and aggressively. This may require recovery in the labor and delivery unit or provision of L&D nursing expertise in the surgical recovery area or ICU. Remember that systemic pain medications will decrease fetal heart rate variability, so regional techniques should be used when possible. Pregnant patients are at high risk for thromboembolism and should be mobilized as quickly as possible - another reason for aggressive postoperative pain management. Maintain maternal oxygenation and left uterine displacement. Notify the Pediatrics Service if the fetus is a viable gestational age so they can provide counseling to the parents if preterm labor occurs.

SPECIAL SITUATIONS

There are also specific anesthetic considerations for unusual situations such as trauma, neurosurgery, cardiopulmonary bypass, fetal surgery, and laparoscopic procedures.

Appendectomy and adnexal masses are the most frequent conditions needing surgical treatment. In one study parturients undergoing appendectomy had an 18% incidence of postoperative pulmonary edema or ARDS. Risk factors for development of pulmonary edema were gestational age greater than 20 weeks, preoperative respiratory rate over 24 breaths per minute, preoperative temperature greater than 100.4 degrees (F), a fluid load (I>O) greater than 4 liters in the first 48 hours, and concomitant tocolytic use. Anesthesiologists should use conservative fluid management in these patients and be prepared to initiate central monitoring should fluid overload occur.

Trauma is a leading cause of maternal death. Fetal loss in these situations is due to maternal death or placental abruption. An early ultrasound should be performed in the emergency room to determine fetal viability. The mother should receive *all* needed diagnostic tests to optimize her management, with shielding for the fetus when possible. Exposure to less than 5 rad does not increase risk to the fetus. Ultrasound and MRI do not utilize ionizing radiation and may be safer. There are few indications for an emergent cesarean delivery. These would include: 1) a stable mother with a viable fetus in distress, 2) traumatic uterine rupture, 3) a gravid uterus interfering with intra-abdominal repairs in the mother, and 4) a mother who is unsalvageable with a viable fetus. If the fetus is pre-viable or dead, focus on optimizing the mother's condition. She will tolerate vaginal delivery at a later time better than an emergent laparotomy for cesarean delivery.

Neurosurgical procedures such as aneurysm or AVM repair may be required in this age group. Any of the usual anesthetics can be used, but fetal monitoring may be helpful when certain techniques are planned. Induced hypotension reduces uterine perfusion, although all agents (nitroprusside, nitroglycerin, hydralazine, esmolol, inhalational agents) have been used successfully during pregnancy. Fetal monitoring will help determine if uterine perfusion is significantly impaired, but the anesthesiologist should still do what is necessary for optimal care of the mother. At the same time, notify the neurosurgeon of your concerns. Hyperventilation reduces maternal cardiac output and decreases oxygen release to the fetus by shifting the oxyhemoglobin dissociation curve to the left. In animal studies, very high doses of

mannitol cause fetal dehydration, but this is probably not a real clinical concern. Endovascular treatment of acutely ruptured intracranial aneurysms has been successfully done during pregnancy. Fetal shielding should be used.

Cardiac surgery requiring bypass has also been successfully performed during pregnancy. The increase in blood volume and cardiac output is maximal at 28-30 weeks, and this is a high-risk time for cardiac decompensation in parturients with cardiac lesions. Another high-risk period occurs immediately postpartum. After delivery, the release of aortocaval compression and autotransfusion of uteroplacental blood increases cardiac output to its maximal. Women who have severe cardiac symptoms during pregnancy, unresponsive to medical management, may benefit from surgery to replace stenotic or incompetent valves. If possible, surgery should be performed during second trimester when the major risk of teratogenicity (from cardiac drugs, x-rays, low-flow or hypoxic states) is past and preterm labor is less likely. However, combined cesarean delivery and valve replacement has been done successfully. Do not withhold surgery if it is indicated for maternal reasons; maternal mortality is comparable to the nonpregnant state.

After 24 weeks gestation, monitor the fetus and maintain left uterine displacement to optimize uterine perfusion. Optimal pressures and flows on bypass are unknown and controversial. Fetal monitoring is a very sensitive measure of perfusion and can be used to optimize these values. Fetal bradycardia commonly occurs at the onset of CPB and slowly returns to a low normal rate with little or no beat-to-beat variability. Hypothermia has been used successfully, although some authors advocate warm bypass. Optimizing the mother's condition is the best way to ensure a good outcome for the fetus.

Fetal surgery is only being performed at a few centers and for limited indications. The major problems are postoperative preterm labor and maternal morbidity due to pulmonary edema. Patients often receive preoperative indomethacin and perioperative magnesium sulfate for tocolysis. High doses of inhalation agents are used for maternal and fetal anesthesia and for uterine relaxation during surgery.

Laparoscopic procedures have been used to avoid unnecessary laparotomy when abdominal pain presents a diagnostic challenge during pregnancy, as well as for some common surgical procedures such as cholecystectomy. Animal investigations have shown that CO₂ pneumoperitoneum does not cause any significant fetal hemodynamic changes, but does induce a fetal respiratory acidosis. Normalizing maternal ETCO₂ produces late and incomplete correction in the fetus. Maintain intra-abdominal pressure as low as possible and keep operative time (and therefore insufflation time) to a minimum. Consider an arterial line for blood gases to completely normalize maternal pCO₂ if the procedure is long or difficult. Other technical alterations during pregnancy should include fetal shielding during cholangiograms, pneumatic stockings, left lateral table rotation, and an open technique for trocar placement.

CONCLUSIONS

Surgery may be necessary during pregnancy. Anesthesiologists should reassure the mother that anesthetic drugs and techniques do not put her fetus or the pregnancy at risk. Prevention of preterm labor is the greatest concern and may require perioperative use of tocolytics. Good postoperative pain management without sedation will aid in early diagnosis and treatment of preterm labor and mobilization to prevent thrombotic complications.

FURTHER READINGS

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7. Shiono PH, Mills JL. Oral clefts and diazepam use during pregnancy. *NEJM* 1984;311:919-20
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Table 1. Documented teratogens. (Adapted: ACOG Educational Bulletin #236, 1997)

ACE inhibitors	Lithium
Alcohol	Mercury
Androgens	Phenytoin
Antithyroid drugs	Radiation (>0.5 Gy)
Carbamazepine	Streptomycin/kanamycin
Chemotherapy agents	Tetracycline
Cocaine	Thalidomide
Coumadin	Trimethadione
Diethylstilbestrol	Valproic acid
Lead	Vitamin A derivatives

Table 2. Principles for anesthetic management of the parturient < 24 weeks gestation.

- Postpone surgery until second trimester, if possible.
- Request preoperative assessment by an obstetrician.
- Counsel the patient preoperatively (see text).
- Use at least a nonparticulate antacid as aspiration prophylaxis.
- Monitor and maintain oxygenation, normocarbia, normotension, and euglycemia.
- Use regional anesthesia for postop pain management when appropriate.
- Document fetal heart tones before and after the procedure.

Table 3. *Principles for anesthetic management of the parturient > 24 weeks gestation.*

- Counsel the patient preoperatively (see text).
- Discuss use of perioperative tocolytic agents with the obstetrician.
- Use aspiration prophylaxis of choice.
- After ~ 24 weeks, maintain left uterine displacement perioperatively.
- Monitor and maintain oxygenation, normocarbia, normotension, and euglycemia.
- Use fetal monitoring intraoperatively when feasible to optimize the intrauterine environment.
- Monitor for uterine contractions postoperatively.