Surgery for the obstetric patient

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Each year approximately 50,000 women require surgery during pregnancy. It is the purpose of this paper to review the anatomical and physiological changes which occur during pregnancy, and to review the effects of anesthetics on the embryo and fetus. The indirect effects of anesthetic drugs and procedures on the uteroplacental circulation, and the practical considerations for the pregnant patient who requires surgery will be discussed.

There is no guarantee that the anesthetist who chooses not to participate in obstetrics will not be called upon to care for the pregnant patient. Each year approximately 50,000 pregnant women receive an anesthetic; the incidence is 0.3-1.6%. Maternal mortality of obstetrical patients who undergo surgery is not increased as compared to that of obstetrical patients who do not undergo surgery, but perinatal mortality is between 6-35%. For the sake of fetal safety, it is best to avoid non-emergency surgery.

The pregnant patient may present with a variety of complications requiring surgical intervention. Ovarian cysts, which are usually found during the first and second trimester, have an incidence of 1:2500. Acute appendicitis seems to be the most common emergency situation. Repair of the incompetent cervix (Shirodkar suture and McDonald procedures) is not uncommon during the first and second trimesters. There have even been reports of critical conditions that have been survived by the pregnant patient; these include intracranial tumors and aneurysm, cardiac disease, pheochromocytoma, hyperthyroidism, and severe diabetes. The pregnant patient is also vulnerable to trauma.

What should the anesthetist be concerned about when caring for the pregnant patient? Objectives for optimal outcome include: (1) Awareness of maternal physiologic changes; (2) Prevention of adverse effects to the fetus by avoidance of the use of teratogenic drugs and prevention of intrauterine asphyxia; and (3) Prevention of premature labor.

Maternal physiologic changes are due to hormonal secretions of the corpus luteum and placenta and to the mechanical factors produced by the growing uterus. These changes alter the patient's response to anesthetic techniques and drugs. The nurse anesthetist must be aware of these changes to ensure that a safe anesthetic is administered.

There is a progressive increase in total blood volume after the eighth week until term, when total blood volume reaches levels approximately 35-40% above pre-pregnancy values. This is reflected partly by an increase in red cell volume, but more so by an increase in plasma volume. Most of this volume is distributed to the uterus, placenta, fetus, breasts, and kidneys through an increase in cardiac output. The cardiac output increases to approximately 40% above pre-pregnancy values.
Cardiac output is greatly influenced by position and aortocaval compression. Total peripheral resistance is decreased, resulting in a slight decrease in blood pressure. (Figure 1)

Clinically, the pregnant patient may present with a lower hemoglobin count and appear to be physiologically anemic. Folic acid and iron supplements will help prevent this. Aortocaval compression and hypotension must be avoided. The patient should not be in a supine position during the second or third trimester. Uterine displacement or tilt can be achieved with the use of a wedge or folded towels under the right hip or a 15° tilt of the table to the left. If regional anesthesia is to be used, it must be remembered that the obstetrical patient will be more prone to hypotension. With distention of the peridural venous plexus, there will be engorgement of epidural veins, a resultant decrease in epidural capacity, and blocking of the intravertebral foramina. The dose of local anesthetics for the parturient should be decreased by one-third to one-half for a subarachnoid block because of the resultant decrease in cerebrospinal fluid volume. (Figure 2)
Blood constituents change with the increase in plasma volume. The platelet count increases as do the plasma levels of fibrinogen and other clotting factors. With decreased fibrinolytic activity and increased clotting factors, the patient is more susceptible to thromboembolic phenomena.

Uterine blood flow is directly proportional to maternal blood flow and indirectly proportional to uterine resistance. Factors which decrease uterine blood flow include hypotension, hypertension, endogenous and exogenous vasoconstrictors, and hyperventilation. Maternal blood pressure should not be allowed to fall more than 15-20% of pre-existing pressure, or less than 100 torr. If it becomes necessary to administer a vasopressor, the use of alpha agonists should be avoided. Ephedrine and mephentermine are the vasopressors of choice. Halothane and enflurane have been shown to produce a dose related depression on uterine contractility.

Respiratory parameters change due to the growing uterus. The diaphragm rises but the total lung capacity is maintained because of compensatory increase in anteroposterior diameter and flaring of the ribs. (See Figure 3) Due to the elevation of the diaphragm, there is a decrease in the functional residual capacity (10% at six months, 20% at term). Alveolar ventilation increases approximately 70% above pre-pregnancy values due to an increase in tidal volume and respiratory rate. Oxygen consumption increases by 20% to supply the needs of the fetus. Arterial blood gases reflect changes due to hyperventilation with the following parameters: increased oxygen partial pressure to 90-106 torr, decreased carbon dioxide partial pressure to 32 torr, decreased bicarbonate, and pH essentially unchanged.

The pregnant patient is much more susceptible to hypoxia even during brief periods of apnea or airway obstruction. Pre-oxygenation for 5-6 minutes should precede induction of general anesthesia. Due to enhanced alveolar ventilation, induction and emergence will be more rapidly achieved. Concentrations of agents which do not render the surgical patient unconscious may anesthetize the obstetrical patient: animal studies have shown the MAC of halothane to be decreased by 25%, methoxyflurane by 32%, and isoflurane by 40% during pregnancy. There is capillary engorgement throughout the respiratory trace, thus great care must be taken when performing nasal intubation or insertion of a nasal airway or nasogastric tube to avoid epistaxis.

Pregnant patients are more susceptible to re-
gurgitation. There is delayed emptying time of the stomach, decreased lower esophageal sphincter tone, impaired competence of the gastroesophageal sphincter and increased intragastric pressure. Twenty-five to seventy percent of pregnant women complain of heartburn. Narcotics, diazepam and anticholinergics also decrease lower esophageal sphincter tone. Shnider suggests intubation for all pregnant patients undergoing surgery in the third trimester, or anytime during pregnancy if signs and symptoms of esophagitis are present. Antacids will raise the pH of the gastric juices, and while they may help decrease the morbidity of aspiration, they do not prevent aspiration. (Figure 4)

Serum pseudocholinesterase activity decreases approximately 21% in the first trimester and remains stable the remainder of the pregnancy. Clinically there are no problems seen with moderate doses of succinylcholine.

With the increase in blood volume, there is an increase in renal blood flow and glomerular filtration. Creatinine, blood urea nitrogen (BUN) and uric acid levels are decreased in pregnancy.

**Effects of anesthesia on fetal development**

A teratogen refers to environmental or genetic factors responsible for producing adverse morphological, biochemical or behavioral fetal effects. In order for a defect to occur, a teratogen must be given in an appropriate dose in the developmental stage and to a susceptible species. The greatest period of sensitivity is that of organogenesis, which occurs during the first trimester. If damage is generalized, a miscarriage will usually occur, whereas localized damage may result in a congenital anomaly.

It is interesting to note that in one study, more than 75% of the patients taking thalidomide delivered normal infants. A definite correlation between anesthetic drugs and fetal defects has not been established because of the many factors responsible for anomaly production. Drug exposure is only one factor. Other factors include maternal hypoxemia, hypercarbia, infection, stress, radiation, and malnutrition. Perhaps the most important factor is the parent's genes. Almost all anesthetics cross the placenta, therefore one can assume that anesthetics have the potential for anomaly production if they are proven to be teratogens.

Animal studies have been performed to determine how anesthetics affect embryo development, but they are sometimes difficult to interpret. The concentrations and duration of anesthetics used during the studies are far in excess of normal clinical usage. Because of this and a lack of control, the applicability of animal studies has not been determined.

Three out of four studies suggest an association between minor tranquilizers and an increased risk of congenital anomalies. The prenatal records
of 19,000 women showed that those who had taken meprobamate (Equanil®) or chlordiazepoxide (Librium®) showed an increase in anomalies when these medications were prescribed during the first six weeks of gestation. The Finnish Register of Congenital Malformation (1967-1971) reported an association of cleft palate with the use of diazepam and meprobamate. A third study showed that mothers of infants with cleft lips reported the use of diazepam four times more frequently than mothers of infants with other defects. A fourth study of more than 50,000 pregnant women did not show an increase in congenital malformations with minor tranquilizers.

Although the studies were not conclusive, they did suggest a strong association. In November, 1975, the Food and Drug Administration (FDA) stated that “while these data do not provide conclusive evidence that minor tranquilizers cause fetal abnormalities, they do suggest an association. Since the use of these drugs during the first trimester of pregnancy is rarely a matter of urgency, benefit/risk considerations are such that their use during this period should almost always be avoided.”

Shnider postulates that hypoxia and hypercarbia induced by narcotics, rather than the narcotics themselves, are responsible for teratogenic effects. Of the inhalational agents nitrous oxide has been studied the most extensively. When 50% nitrous oxide was administered to rats for 1-32 days, there was a high incidence of intrauterine death and increased skeletal malformations. Incubating chicks exposed to 80% nitrous oxide showed similar effects.

Halothane, enflurane (Ethrane®), methoxyflurane, fluoroxene, diethyl ether and cyclopropane have produced anomalies in animal studies. Low concentrations of halothane given for 12-48 hours produced anomalies in rat fetuses. Cleft palates and paw defects were produced when halothane 1.5% was administered to pregnant mice for three hours. Halothane 0.6% given to pregnant hamsters for three hours produced increased abortion mid trimester. Methoxyflurane 0.5%, produced an increased incidence of embryonic deaths and multiple anomalies when chick embryos were exposed to it. Muscle relaxants cross the placenta to an extent, but there is no evidence that normal clinical doses have any adverse effects on human fetal development.

Local anesthetics have the lowest blood levels reaching the fetus when administered in the subarachnoid space. Accidental intravascular injection following an epidural produces very high blood levels. Bupivacaine, prilocaine, and etidocaine injected into rabbits and rats did not demonstrate teratogenesis. For obvious reasons, very few human studies have been done. It is difficult to say that anesthesia does not cause teratogenesis, but those studies performed have not shown an increase in anomalies. No anesthetic agent in clinical usage appears to be a teratogen. Studies performed in the U.S. and Great Britain have suggested that females administering anesthesia and wives of male anesthetists have an increased rate of spontaneous abortion. The reliability of these studies has been open to question. Several surveys of women who have received an anesthetic during pregnancy have shown no increase in anomalies.

Werboff and Gottlieb first used the term behavioral teratology to describe the adverse action of a drug on “behavioral or functional adaptation of the offspring to its environment.” Currently there is no evidence that anesthesia adversely affects mental and neurological development in infants.

Special concerns

The uteroplacental circulation is indirectly and easily affected by drugs and anesthetic procedures. Fetal oxygenation is dependent upon oxygen capacity, oxygen affinity and maternal oxygenation. Hypoxic situations must be avoided. Laryngospasm, airway obstruction and low inspired oxygen concentrations may cause hypoxia. Uteroplacental perfusion may be decreased following maternal hypotension, which can be secondary to hemorrhage, regional anesthesia, aortocaval compression, and deep anesthesia. Increased uterine activity may also decrease perfusion.

Ketamine in doses of 1 mg/kg or more will increase uterine tone. Sympathomimetics will increase uterine vascular resistance. The use of alpha agonists such as methoxamine must be avoided. Although the infusion of epinephrine has been shown to decrease uterine blood flow in experimental animals, it is still controversial as to whether this occurs with the addition of small amounts of epinephrine to local anesthetics used for epidural anesthesia.

No study has shown that any anesthetic agent or technique has been associated with a higher or lower incidence of premature labor. Onset of premature labor seems to be more closely related to the surgical pathology and degree of manipulation, especially in the pelvic organs, during the operative procedure.

For practical reasons, only emergency surgery should be performed during pregnancy.
tive procedures should be delayed until physiological changes return to normal, which is approximately six weeks postpartum. Preoperative assessment of all women of child bearing age should include a check for possible pregnancy. Urgent surgery should be deferred whenever possible until the second or third trimester. Although no anesthetic drug has been proven to be teratogenic in humans, it is best not to expose a fetus to drugs during the first trimester.

As with any emergency surgery, it is important to allay apprehension. The pregnant patient is likely to be very concerned about an unplanned surgical procedure and may have an increased level of catecholamines. Premedication should not be withheld, especially if the patient is in pain. Meperidine (Demerol®) and morphine are the most commonly used analgesics. Barbiturates are preferable to tranquilizers. Glycopyrrolate does not cross the placenta as does atropine. Cimetidine has not been approved by the FDA for use in pregnant women.

If general anesthesia is to be used, one must decrease the risk of aspiration. Antacids should be administered 30 minutes prior to induction. Premedication should precede a rapid controlled induction and cricoid pressure should be maintained until the cuff is inflated. It is best to use those anesthetics that have had the safest histories for the longest period of time. These include thiopental, up to 4 mg/kg for induction, and possibly ketamine, 0.5-0.75 mg/kg for the hypovolemic patient. Analgesic concentrations of halothane 0.5% or enfurane 0.75% with low concentrations of nitrous oxide are preferable. Succinylcholine and d-Tubocurarine may be added for muscle relaxation. Hyperventilation must be avoided, and arterial blood gases should be monitored during long and difficult procedures. (Figure 5)

To avoid hypotension when regional anesthesia is used, the patient should be preloaded with lactated Ringers solution intravenously. Dextrose-containing solutions should not be used for prehydration to avoid neonatal hypoglycemia. The dose of local anesthetic should be decreased by one-third to one-half. If maternal blood pressure decreases more than 15% from baseline or below 100 torr, small doses of ephedrine or mephentermine may be administered intravenously.

With either technique, lateral uterine displacement will help prevent aortal caval compression. Fetal heart tones should be monitored.
throughout surgery whenever feasible with the use of a Doppler or fetal heart monitor after the sixteenth week of gestation. Fetal as well as maternal monitoring needs to be extended into the recovery room to insure that the patient does not become hypoxic or hypercarbic and that the fetus continues with good fetal heart tones.

REFERENCES

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February/1984 47