Pregnancy-Related Physiological and Anatomical Changes

Numerous changes occur in a woman's body during pregnancy. These changes affect almost every organ system. Changes early in pregnancy are largely due to increases in hormones (i.e., progesterone and estrogen) and increased metabolic demands of the fetus, placenta, and uterus. Later changes are due to the expanding uterus and growing fetus. All of these changes impact anesthetic care.

I.Cardiovascular System changes

1.Blood Volume

Blood volume will increase progressively starting at 6-8 weeks. At the time of delivery, the average blood volume is increased by 1-1.5 liters. There is a greater increase in plasma volume compared to red blood cell mass, resulting in relative anemia. The clotting components of the patient's blood also increase to enhance clotting, reducing excessive bleeding during delivery. These components include fibrinogen, and factors VII, X, and XI. Increased blood volume meets the mother and fetus's metabolic demands, allowing the mother to tolerate blood loss during delivery. The average blood loss associated with vaginal delivery is 400-500 ml. With a cesarean section, it is 800-1000 ml.

2.Cardiac Output

Cardiac output will increase up to 40% at term. Most of the increase occurs in the 1st and 2nd trimesters. The exception is during labor when cardiac output peaks secondary to increased heart rate and stroke volume (the volume of blood ejected from the heart with each 2 contraction). To handle the increased blood volume, the myocardium and chambers enlarge. Cardiac output will return to normal 2 weeks after delivery. Cardiac output can decrease after 28 weeks of pregnancy due to mechanical changes.

3.Blood Pressure

Despite increases in the patient's cardiac output and blood volume, the patient's blood pressure does not normally increase from pre-pregnancy levels unless there is an abnormality such as pregnancy-induced hypertension. A decrease in blood pressure occurs by about 8 weeks of gestation. By mid-pregnancy, the diastolic blood pressure and mean arterial pressure reach their lowest point (16-20mmHg below pre-pregnancy values), returning to pre-pregnancy levels by term. The overall decrease in diastolic blood pressure and mean arterial pressure is 5-10 mmHg.

4. Venous System

The venous system has an increased capacity for distension and dilation (up to 150%). This can reduce blood flow, delaying the absorption of subcutaneous or intramuscular medications. Distention of the vessels within the epidural space may increase the risk of vascular damage and bleeding during neuraxial blockade. This, along with hormonal changes, reduces the required amount of local anesthetics by 30%. Using the same dose in the pregnant patient as normally would in the non-pregnant patient results in a high neural block.

Anesthetic considerations due to Cardiovascular Changes in pregnancy:

a) Never lay the patient supine. Always place a wedge or roll under the right hip so the patient is "tipped" to the left. This maneuver will prevent a decrease in cardiac output, maternal hypotension, fetal distress, or asphyxia that can result from supine hypotension syndrome/aortocaval compression.

b) The pregnant patient is dependent upon sympathetic outflow to maintain systolic blood pressure. Always pre-load the patient with 1-2 liters of crystalloid fluids before the neuraxial blockade.

c) Vessel distention in the epidural space may increase the risk *of* vessel damage during *the* neuraxial blockade.

d) Vessel distention also decreases the intrathecal and epidural spaces. Decrease the dose of local anesthetics by 30% to avoid a high neuraxial block.

e) Delayed absorption of subcutaneous and/or intramuscular medication.

II.Respiratory System changes

1. Lung Volumes

As the gravid uterus grows in size, it places pressure on the abdomen. At term, the pregnant patient favors thoracic breathing over abdominal breathing. The most important is the change in functional residual capacity (FRC- the volume of air that is in the lungs at the end of a normal breath).

FRC decreases 20% by term, returning to normal 48 hours after delivery. A decrease in FRC reduces the patient's reserve. In the event of apnea, the patient can become hypoxic quickly. In addition, the pregnant patient will increase her tidal volume (normal volume with each breath) by 40%.

2. Respiratory Gas Exchange

Minute ventilation (amount of air breathed in one minute) increases by 50% by the second trimester. The respiratory rate will increase by 15% (2-3 breaths per minute). These changes speed the uptake of inhaled anesthetics. Alveolar ventilation (air that participates in gas exchange) will increase by 70% at term. Oxygen consumption increases by 20-50%. The combination of a decreased FRC and increased oxygen consumption can result in hypoxia.

3. Respiratory Tract

As mentioned earlier, the pregnant patient has venous vascular engorgement, which results in a swollen respiratory tract and a diminished view during laryngoscopy. The obstetric population is more difficult to intubate compared to the non-pregnant population. A smaller-than-usual endotracheal tube may be required. Manipulation during laryngoscopy can result in bleeding, obscuring the view of the glottic opening.

Anesthetic considerations due to *Respiratory c*hanges in pregnancy: Patients undergoing regional anesthesia should have supplemental oxygen.

a) Patients undergoing general anesthesia should be pre-oxygenated with 100% O2 *before* induction.

b) Patients may desaturate despite pre-oxygenation due to increased oxygen consumption and decreased FRC.

c) Be prepared for difficult intubation. Swollen mucous membranes may decrease visualization. Ensure the patient is positioned optimally for laryngoscopy.

d) Have smaller endotracheal tubes available for intubation. A smaller endotracheal tube may be required for intubation due to swollen tissue.

e) Be very gentle during laryngoscopy as bleeding may obstruct the view.

III.Renal system changes

The pregnant patient's renal plasma flow and glomerular filtration rate will increase by 50-60% at term. This correlates with increased cardiac output and blood volume. Increases in renal plasma flow and glomerular filtration rate result in increased clearance of blood urea nitrogen and serum creatinine, which may be reduced by 40%. Obstructive changes to the renal system can occur due to the enlarging uterus. This may result in increased urinary tract infections and decreased blood flow to the kidneys.

IV.Gastrointestinal system changes

Mechanical and hormonal alterations result in several changes within the gastrointestinal system. As the uterus enlarges, pressure is placed on the stomach resulting in an incompetent lower esophageal sphincter. In addition, progesterone will reduce the competence of the lower esophageal sphincter. Placental gastrin causes an increased secretion of gastric acid. These changes lead to the reflux of gastric acid into the esophagus and delayed gastric emptying and place the pregnant patient at risk for aspiration during anesthesia.

Anesthetic considerations due to gastrointestinal changes in pregnancy:

Pregnant patients should be considered to have *"full stomachs"*, regardless of fasting.

a) If available, medications should be administered *before* anesthesia to reduce gastric acidity and volume. A non-particulate antacid (i.e., sodium citrate), Metoclopramide (Plasil) 10 mg IV should be administered 30-60 minutes *before* anesthesia to stimulate gastric emptying and increase lower esophageal sphincter tone. The use of histamine H2 *blockers* 30-60 minutes *before* surgical intervention may help to reduce the acidity of stomach contents.

b) Position the patient with a roll under the right hip. A slight reverse Trendelenburg position may *help prevent* passive reflux.

c) Cricoid pressure should be applied and held until the patient is intubated. Cricoid pressure should not be released until it is confirmed that the endotracheal tube has been placed in the trachea.

d) Do not routinely administer positive pressure ventilation, with a mask, *before* intubation. Positive pressure ventilation should occur if the patient's pulse oximetry reading starts to decline or a difficult airway is encountered. Unnecessary positive pressure ventilation *before* intubation may result in gastric distention, placing the patient at risk for aspiration.

Hepatic system changes

The overall function and blood flow to the liver are unchanged during pregnancy. There is a 25-30% decrease in pseudocholinesterase function at term. In the immediate delivery period, this should not produce a clinically significant prolongation of succinylcholine, mivacurium, or ester local anesthetics.

VI.Central nervous system changes

Changes in hormones result in a decrease of up to 40% in minimal alveolar concentration (MAC). By the 3rd-day post-delivery MAC levels return to normal. Hormonal changes and venous dilatation contribute to a 30% decrease in local anesthetic requirements for spinal and epidural anesthesia. Anatomical changes may create an epidural space that has positive pressure instead of negative pressure.

Anesthetic considerations due to *Central nervous system* Changes in pregnancy:

a) Reduces the dose of inhaled anesthetics by up to 40%.

b) Reduces the dose of local anesthetics for spinal and epidural anesthesia by up to 30%.

c) Positive pressure in the epidural space may make it slightly more difficult to identify the epidural space.

MCQ test

1- The average blood loss associated with vaginal delivery is:

a) 200-250ml.

b) 250-400ml.

c) 400-500ml.

d) 500-1000ml.

e) 800-1000ml.

2- The dose of local anesthetics for spinal anesthesia in pregnancy reduced by up to:

a) 30%.

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b) 20%.

c) 40%.

d) 60%.

e) 5%.

3- Regarding anesthesia for pregnant lady(all true except one)

a) Pregnantlady should be considered to have “full stomachs”, regardless of fasting.

b) Reduces the dose of inhaled anesthetics by up to 40%.

c) Cricoid pressure should not be released until it is confirmed that the endotracheal tube has been placed in the trachea.

d) Always administer positive pressure ventilation, with a mask, before intubation.

e) A non-particulate antacid and Metoclopramide given before anesthesia to increase lower esophageal sphincter tone.

4- All the following parameters are increase in pregnancy except one

a) FRC.

b) Blood volume.

c) GFR.

d) Minute ventilation.

e) Cardiac output.

5- Which one is true regarding physiological changes in pregnancy

a) the pregnant patient has venous vascular engorgement, which results in a swollen respiratory tract.

b) The overall function and blood flow to the liver are huge changes during pregnancy.

c) Patients may desaturate despite pre-oxygenation due to decreased oxygen consumption and increased FRC.

d) Cardiac output will return to normal 20 weeks after delivery.

e) increase in plasma volume compared to red blood cell mass, resulting in polycythemia.