

SECTION: Obstetrical/Gynecological Emergencies

PROTOCOL TITLE: Physiologic Changes with Pregnancy

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OVERVIEW:

Many changes occur in the pregnant woman's body, starting from the time of conception and throughout the pregnancy. The most obvious body system to undergo change is the reproductive system, but all of the others will change as well. Brief summaries of the physiologic changes that occur during pregnancy have been listed by system. Most of these physiologic changes will resolve during the postpartum period.

Respiratory System:

As the uterus enlarges during pregnancy, it causes the diaphragm to rise, decreasing the resting lung volume, and decreasing the Functional Residual Capacity (FRC).

The tidal volume (volume of air inspired and expired during each breath) increases throughout pregnancy by 40%, which in turn causes the minute ventilation (volume of air inspired or expired in one minute) to also increase by 40%. Because of this hyperventilation (which is caused by the increasing presence of progesterone), there is an increase in the arterial PO_2 to 106 - 108 mmHg, and a decrease in the arterial PCO_2 to 27 - 32 mmHg. These changes are reflected in the appearance of a respiratory alkalosis on an ABG.

Another change occurring during pregnancy is the increase in total body oxygen consumption by about 15 – 20%. This is secondary to the increased requirements of the cardiac and renal systems, with additional requirements from the extra work of respiratory muscles and breasts (in preparation for lactation).

Lastly, the upper respiratory passages are engorged secondary to increased vascularity, predisposing the pregnant patient to nasopharyngeal bleeding, transient blockage of the Eustachian tubes, and nasal stuffiness.

Cardiovascular:

Total blood volume increases by 50% during pregnancy. The bone marrow will increase the production of RBC's, but the plasma component of the blood volume increases more rapidly, causing an "anemia of pregnancy". Normal hemoglobin is 12 g, and normal hematocrit is 31 - 34%. The WBC count also increases slightly to 9,000 to 12,000 / μ L. Because of this increased blood volume, the cardiac output is increased by 1 – 1.5 L / minute.

Due to the increasing size of the uterus, the mother's heart is elevated and rotated forward to the left. The patient's heart rate rises gradually throughout pregnancy, to an increase by 12 - 18 beats / minute. Palpitations early in the pregnancy are caused by disturbances in the sympathetic nervous system, while palpitations toward the end of gestation are the result of increasing intra-abdominal pressure of the enlarged uterus.

Baseline arterial blood pressures decrease during pregnancy, and are at their lowest values at 20 - 24 weeks gestation. This is due to the increased cardiac output, and reduced peripheral vascular resistance. They will gradually rise to pre-pregnancy values at term, when vasoconstrictor tone increases. Systolic BP decreases by 4 - 6 mmHg, diastolic BP decreases by 8 - 15 mmHg, and the mean BP decreases by 6 - 10 mmHg.

Hypertension in pregnancy is usually indicative of an obstetrical complication, such as preeclampsia.

Blood pressure is further affected by position. As the pregnancy progresses, the enlarging uterus displaces and compresses the iliac veins, inferior vena cava, and the aorta. When the pregnant woman is in the supine position, this causes increasing venous compression, decreasing venous return, and cardiac output. This may cause a significant hypotension, which in turn may cause nausea, dizziness, or syncope. These symptoms can be relieved by turning the patient on her side, either right or left lateral recumbent.

Venous compression can also cause complications such as varicose veins, hemorrhoids, and edema in the lower extremities.

Gastrointestinal:

Hormonal changes (progesterone) cause the gastro-esophageal sphincter to relax, as well as all of the muscular tone around the stomach and esophagus. This can cause prolonged gastric emptying time, constipation, heartburn, and gastro-esophageal reflux.

The enlarging uterus displaces the stomach and intestines upward, which can also contribute to GE reflux. The gradual stretching of the abdominal wall alters the normal response to peritoneal membrane irritation. The pregnant patient may not be able to note tenderness. The appendix may also be displaced laterally and upward.

Liver function tests (LFT's) may be altered and alkaline phosphatase isoenzymes that are produced by the placenta cause the total alkaline phosphatase levels to nearly double. Serum cholinesterase levels are also decreased while serum leucine aminopeptidase activity is markedly elevated.

The pregnant patient is also more prone to gallstones because of prolonged emptying time from decreased tone and incomplete evacuation of the gallbladder secondary to distension.

Urinary and Renal:

The pregnant patient may experience urinary frequency during the first months of pregnancy because of hormonal effects, and because of pressure on the bladder caused by the enlarging uterus. UTI's and / or cystitis are common secondary to urinary stasis, and ineffective emptying of the bladder.

There usually is an increase in the amount of urine, and the specific gravity is lower. The spilling of glucose in the urine is not uncommon, as there is a decreased renal threshold for glucose. This should be monitored closely, however, as it may be indicative of pregnancy induced diabetes mellitus. Renal function tests may indicate decreases in the following values: plasma creatinine (< 0.7 mg / dL), urea concentrations (< 10 mg / dL), and urine concentration. Renal plasma flow and the glomerular filtration rate (GFR) increase to 40% greater than pre-pregnancy levels. Plasma levels of renin, renin substrate, and angiotensin I and II will increase.

The ureters, especially the right, become markedly dilated. This is secondary to endocrine influences, causing a softening of the ureteral walls and also from pressure on the ureters from the uterus as they arise out of the pelvic ring.

Integumentary:

Striae Gravidarum (“stretch marks”) appear over the abdomen and breasts of a pregnant woman. These elongated streaks, of pink and red, are the results of the rapid stretching of skin and the underlying connective tissues during the rapid weight gain associated with pregnancy.

Chloasma is the “mask of pregnancy”, an increase in facial pigmentation occurring over the nose and cheeks. Increased pigmentation can also occur as a dark line extending from the mons pubis to the umbilicus. This is referred to as *linea negra*.

Due to an increase in circulating estrogens, spider hemangiomas may appear on the skin. These are red blemishes with spider-like legs that branch off from a central body, and tend to be more pronounced on fair-skinned women.

Hormonal increases also can cause an increase of the activity of the sebaceous glands, sweat glands, and hair follicles.

Musculoskeletal:

Increased progesterone levels cause a relaxation of the ligaments supporting the joints. The sacroiliac joint relaxes and widens, as well as the symphysis pubis (by 4 to 8 mm), causing instability of the pelvis. This, in turn, causes additional strain on the thigh and back muscles, and amounts for the swayback, waddling gait of the pregnant patient. The torso also tilts backwards to assist with maintaining equilibrium, as the full term, pregnant uterus can weigh up to 12 pounds.

As the uterus enlarges, it creates tension on the abdominal muscle wall. This tension occasionally becomes so great, that the abdominal recti muscles separate in the median line. This separation is known as *diastasis recti*.

Endocrine:

During pregnancy, the placenta acts as the major endocrine gland. It secretes four hormones that are necessary to maintain the pregnancy: human chorionic gonadotropin or HCG, human chorionic somatomammotropin (also known as human placental lactogen or hPL), estrogen, and progesterone. HCG prolongs the life of the corpus luteum (a structure within the ovary), which in turn produces estrogen and progesterone, which maintains the endometrium (the lining of the uterus). The presence of HCG in the urine is the diagnostic indication of pregnancy. HPL influences the somatic cell growth of the fetus, and prepares the breasts for lactation. Both progesterone and estrogen affect the growth of the uterus and the development of the breasts.

The pituitary gland has two lobes, the anterior and the posterior. During pregnancy, the posterior lobe secretes the hormone Oxytocin, which stimulates contractions during

labor, stimulates the uterus to continue to contract after delivery, and stimulates lactation. The anterior lobe continues to function as usual, except it no longer releases gonadotropins (FSH and LH), and it increases its production of prolactin, the protein necessary for milk production.

The thyroid gland enlarges during pregnancy. This, however, does not cause an increase in thyroid activity. Serum iodine and thyroxine levels increase, but this is due to an elevation in the level of thyroid-binding protein in the blood (probably from an increase in circulating estrogen).

The adrenal glands secrete an increased amount of aldosterone, as early as the 15th week of pregnancy. The hormone aldosterone is responsible for sodium retention by the kidneys. This explains the common problem of fluid retention in pregnancy, and possible edema.

Increased levels of glucocorticoids, estrogens, and progesterone affect glucose metabolism. This change in metabolism, along with the stress of pregnancy, increases the pregnant patient's need for insulin. This may actually induce *gestational diabetes mellitus*.

Reproductive:

The uterus will soften, becomes more globular, and increases in size throughout pregnancy to accommodate the growing fetus, placenta, and amniotic fluid. By the 12th to 14th week of gestation, the uterus has risen out of the pelvis, and is palpable just above the symphysis pubis. By the 16th week, it is at a height between the symphysis pubis and the umbilicus. The uterus can be palpated at the level of the umbilicus by 20 weeks, and is at its highest point, almost at the xiphoid process, by the 36th week. Two to four weeks before labor begins, the fetal head descends back down into the pelvic cavity. Estrogen stimulates hypertrophy of the uterine muscle fibers, which enables the uterus to contract during labor.

The cervix will soften, and the cervical mucus glands will form a mucus plug, that seals the uterus during pregnancy, protecting it from vaginal bacteria. This plug is expelled, along with a small amount of blood, at the end of the pregnancy, before labor begins. This event has been termed as the "*bloody show*".

The mammary glands further develop in pregnancy by stimulation from placental estrogen and progesterone. The ductile system within the breasts will grow from the effects of estrogen, while progesterone enables alveolar glands to develop at the ends of these ducts. The glandular tissue replaces pre-pregnancy adipose tissue in the breasts, causing them to almost double in size. Actual milk production does not occur during pregnancy, as it is inhibited by the presence of progesterone. However, the watery precursor to milk, *colostrum*, may be present.