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**DEPT: BIOMEDICAL ENGINEERING**

**COURSE: PHS212; HUMAN PHYSIOLOGY II**

**ASSIGNMENT**

**Question**

**Elucidate the Physiological adaptations of the female to pregnancy?**

**Answer**

A number of anatomic, physiologic, biochemical and psychological changes take place during pregnancy.

These physiological changes occur;

- A. In the Skin
- B. In the Gastrointestinal system
- C. In the Cardiovascular region
- D. In Blood Volume
- E. In Cardiac Output
- F. In the Heart
- G. In Heart Rate
- H. In Blood Flow and Blood Pressure
- I. In Respiratory
- J. In Renal regions
- K. In Posture and Renal Functions
- L. In Reproductive System
- M. In Muscular Skeletal and Neurology

1. **SKIN CHANGES** - A number of changes take place in the skin of pregnant women. Mechanical stretching of the skin over the abdomen and breasts can lead to stretch marks. The increased levels of estrogen and progesterone have also been implicated. Usually stretch marks remain permanently with some change in color. Prevention may be achieved with moisturizing creams, especially those containing lanolin and other oily substances. Vascular spider nevi (a collection of small, dilated arterioles (blood vessels) clustered very close to the surface of the skin) happen also during pregnancy. There is no clear explanation for these changes, but they most likely represent the result of vasodilatation that happens in the skin during pregnancy. Chloasma and other pigmented lesions can happen as a result of

increased melanocyte-stimulating hormone activity which in turn is a result of increased estrogen and progesterone levels. These lesions usually begin at about five to six months gestation.

**2. CHANGES IN THE GASTROINTESTINAL SYSTEM** - Nausea and vomiting are the most frequent complaints involving the gastrointestinal system and usually happen in early pregnancy while heartburn happen primarily in late pregnancy. The gums become hyperemic and edematous during pregnancy and tend to bleed. The muscular wall of the esophagus is relaxed and this may cause reflux, which in turn can lead to esophagitis and heartburn. The stomach and the intestines have decreased motility presumably due to the effect of progesterone on smooth muscle contractility. This causes an increase in the time that it takes for the stomach to empty. Reduced gastric secretion has also been documented and it could account for the improvement of peptic ulcers sometimes observed in pregnancy. Decreased motility of the large intestine may lead to constipation. The liver is affected significantly by pregnancy. Cholestasis jaundice is considered to be the result of estrogen effect on elimination of bilirubin by the liver. The effect of estrogens also, is to increase protein synthesis in the liver, which leads to increased production of fibrinogen and binding proteins. The liver enzymes are usually unaffected with the exception of alkaline phosphatase, which is increased at approximately two fold to four fold that is a result of a placental production. Pregnancy increases the size and decreases the motility of the gall bladder. The decreasing motility and increase in volume, combined with changes in the bile's composition explains the correlation between the incidence of cholelithiasis and pregnancy.

**3. CARDIOVASCULAR CHANGES**- Of all changes that happen in pregnancy, the single most important is the one involving the cardiovascular system. Adequate cardiovascular adaptation secures good placental development and thus appropriate fetal growth. the cardiovascular changes involves a substantial change in the blood volume, cardiac output, heart rate, systemic arterial blood pressure, systemic vascular resistance, oxygen consumption and alterations in regional blood flow of various organ systems.

**4. CHANGES IN BLOOD VOLUME** - Significant increases in the blood volume start taking place in the first trimester and continue until the mid-third trimester, at approximately the 32nd to the 34th week. Beyond this point in gestation, the blood volume plateaus. The average absolute increase in blood volume during pregnancy is about 1600 ml and in terms of percent change one should expect a 40 to 50 percent increase above pre-pregnancy levels. The increase in the blood volume is achieved by a combination of increases in the plasma volume and the RBC mass. The calculated plasma volume expansion is approximately 1300 ml and the volume of the RBC increases about 400 ml. This discordance in the change between the cellular elements of the blood and the liquid portion leads to the so called "physiologic anemia of pregnancy". Increased estrogen levels in pregnancy cause increased production of renin from the kidneys, the uterus and the liver and thus cause elevated renin plasma levels. The increase in renin, which stimulates aldosterone secretion, is associated with sodium retention and an increase in total body water. The increase in blood volume with pregnancy appears to serve the essential physiologic needs of both the mother and fetus. It ensures adequate supplies required for normal fetal growth and oxygenation even under circumstances that affect the maternal cardiac output (inferior vena cava compression). This increased blood volume also helps normal pregnant women to withstand hemorrhage equal to the volume of blood added to the circulation during the course of the normal pregnancy without any signs of decompensation.

5. **CHANGES IN CARDIAC OUTPUT** - the cardiac output increases an average of 50 percent during pregnancy. It is generally accepted that cardiac output begins to rise during the first trimester, probably around the tenth week of pregnancy and continues to rise up until the 24th week of gestation. Once it reaches the peak it stays rather stable. As pregnancy advances, heart rate increases and becomes a more predominant factor in increasing cardiac output. At the late stages of pregnancy, the stroke volume declines to normal, non-pregnant values.

6. **CHANGES IN THE HEART**-A number of changes happen to the heart and are unique to pregnancy. Increasing intra-abdominal contents displace the heart upward with some forward rotation. As a result the anterior posterior diameter and the cardiothoracic ratio are increased. The overall dimensions of the heart are increased during pregnancy as a result of increased diastolic heart volume without any change in the ventricular wall thickness. Systolic ejection murmurs are common in pregnancy while diastolic murmurs are less frequent. The systolic murmurs are usually the result of the hyper dynamic circulation. Electrocardiogram changes have also been reported during pregnancy.

7. **CHANGES IN HEART RATE**- The baseline heart rate increases by about 10 to 20 beats per minute. This increase starts early in pregnancy and gradually continues to go upward with the highest values achieved at term. In twin gestations, the rise of the heart rate is more pronounced and it can reach as much as 40 percent above the non-pregnant state. A change also from the supine position to the lateral position may cause the heart rate to drop slightly.

8. **CHANGES IN BLOOD FLOW AND BLOOD PRESSURE** – **Concerning Blood Pressure**, there's a slight decrease in the systolic arterial blood pressure and a significant decrease in the diastolic pressure have been observed to occur in normal pregnancy. This decrease becomes evident in the late first trimester and continues throughout most of the second trimester. The lowest values are noted in mid pregnancy and there after the blood pressure returns toward non-pregnant levels before term. The degree of change in the blood pressure parameters has been found to be affected by parity, smoking, preexisting hypertension, maternal age and ethnic background. In the typical normal pregnancy the mean arterial pressure (diastolic plus  $\frac{1}{3}$  of the difference between systolic and diastolic) is less than 85 mm of mercury. Studies have found that when the mean arterial blood pressure in the mid second trimester is higher than 90 mm of mercury, there is increased perinatal mortality and morbidity. **With Blood flow**, the most profound changes in regional blood flow occur in the uterus with a 5 to 10 fold increase. This change starts early in pregnancy and continues until almost term. Approximately 20% of the maternal cardiac output perfuses the uterine vessels (placental and nonplacental). The kidneys also demonstrate substantial increase of the regional blood flow as much as 30 to 80 percent and at the same time a 50 percent increase in glomerular filtration rate is noted. The regional blood flow in the extremities also increases and more so in the hands than the legs. As it was mentioned previously, there is a significant dilatation in the skin vessels which leads to an increase in the regional blood flow. These changes in the skin vessels may cause warm skin, clammy hands, vascular spiders, and palm erythema. The liver circulation is not affected very much and the same is true for the brain blood flow which is auto regulated. The blood flow to the breast is increased during pregnancy to prepare the breast for lactation. The effect of pregnancy on coronary blood flow is still unknown. It is safe, however, to speculate that an increase may happen since augmentation of cardiac function is present during pregnancy.

9. **CHANGES IN RESPIRATORY**- Anatomic Changes Mucosal edema and hyperemia secondary to capillary engorgement are common findings in the nasopharynx and the tracheal bronchial tract. The majority of pregnant women have redness and swelling of the lungs that at times can produce changes in the voice. Changes also occur in chest circumference (6 to 7 cm.), vertical diameter (4 to 5 cm.), and the sub sternal angle (from 70 to 105 degrees). The increase in chest circumference compensates for the elevation of the diaphragm, so that essentially there is no change in the overall volume of the thoracic cavity. In Pulmonary Ventilation, during normal pregnancy the patients are in a state of hyperventilation. The arterial CO<sub>2</sub> declines and the maternal arterial blood pH remains unchanged by compensatory increase in renal excretion of bicarbonate, which decreases to 21 mEq/L from 27 mEq/L. This hyperventilation of pregnancy seems to be related to the direct action of progesterone on the respiratory center. This effect with the lowering of the CO<sub>2</sub> in the blood facilitates removal of CO<sub>2</sub> from fetal cells and produces a CO<sub>2</sub> tension in the fetus similar to what will be found in the newborn. During the labor process the hyperventilation process is augmented and the patients ventilation peak values can reach as high as 40 liters per minute as compared to the 12 liters per minute prior to

10. **CHANGES IN RENAL REGIONS** - The changes in renal function during pregnancy are profound and are surpassed only by those of the cardiovascular system. The kidney size increases only slightly during normal pregnancy. However, the more striking in structural changes are those of the ureters, calyces, and renal pelvis. These changes are readily seen as early as the third month of gestation and remain until approximately the fourth month postpartum. Since these changes appear long before the gravid uterus is large enough to cause mechanical compression of the ureters, a hormonal effect is postulated. Progesterone, a smooth muscle relaxant, is produced in large concentrations even early in pregnancy, and is most likely the cause of the dilatation and decrease in peristaltic activity. Later in pregnancy, mechanical compression must certainly play a role. Interestingly, the dilatation of the upper urinary tract is greater on the right than on the left. The explanation given by some for this phenomenon is that the colon acts as a cushion to protect the left ureter, whereas the right ureter is more exposed. Of all functional renal changes that accompany pregnancy, the most striking is that of glomerular filtration rate (GFR), which increases by approximately 50 percent. Renal plasma flow on the other hand increases by approximately 25 percent. Both begin to change early in the second trimester of pregnancy and in lateral recumbency are maintained at these elevated levels to term. A glomerular tubular balance exists for sodium during pregnancy, this is not the case for glucose or amino acids. The increased glomerular filtration rate leads to a significant glucose excretion that exceeds the tubular maximum for glucose reabsorption leading to glucosuria in many normal patients. A similar aminoaciduria is frequently seen in pregnancy. In compensation for the hyperventilation and hypocarbia that occur with pregnancy, there is an increase in bicarbonate excretion by the kidney.

11. **CHANGES IN POSTURE AND RENAL FUNCTION** - In non-pregnant individuals the up-right posture causes extra cellular fluid to shift to the legs, resulting in a relative decrease in central blood volume. This response is exaggerated during pregnancy and a similar response also occurs when the supine position is assumed. The extent of the change is a 50 to 60 percent decrease in urine flow and sodium excretion in supine recumbency versus lateral recumbency, accompanied by 20 percent decrease in renal plasma flow and glomerular filtration. The underlying patho-physiology is likely to be inferior vena caval obstruction, resulting in pulling of blood in the dilated veins of the lower extremities, dependent edema, decreased venous return, decreased central blood volume, increased aldosterone production, and ultimately decreased urinary excretion of sodium and water.

**12. CHANGES IN THE REPRODUCTIVE SYSTEM** - Rhythmic tightening of the uterus occur as part of preparatory changes for labor. These are called Braxton-Hicks contractions and since the advent of ultrasound, can be seen as early as eight to nine weeks. As the pregnancy advances these contractions become more frequent and they are more likely to be felt by the patient. Usually they happen every 5 to 20 minutes and sometimes they may last as long as 30 minutes. The genital organs undergo significant changes with increased vascularity of the cervix and increased mucous formation by the cervical glands due to increased levels of estrogen. The vulva and the vagina are also edematous and present increased desquamation and transudation. This leads to an increase in the secretions from the vagina manifesting as increased leucorrhoea. The secretions of the vagina are acidic because of the conversion of an increased amount of glycogen in the vaginal epithelial cells by Doderlein's Bacilli into lactic acid. Many patients experience perineal pressure pain, which may be secondary to vascular engorgement of tissues due to estrogen and stasis of blood and to pressure from fetal presenting parts. Pubic pain is also noted and may be secondary to increased joint motility that happens secondary to progesterone's relaxing effect on the pubic symphysis cartilage. Many women experience pain in the region of the round ligament, which is secondary to stretching as the uterus grows.

**13. CHANGES IN MUSCULAR SKELETAL AND NEUROLOGIC SYMPTOMS** - A number of women may experience backache in the upper back, which is secondary to muscle tension from increasing breast size and discomfort. Most women, however, experience low back pain secondary to muscular fatigue and strain that is caused by the changes in body balance from the growing uterus. Several women also may experience pressure on nerve roots that in turn may lead to muscular spasms and pelvic joint pains secondary to bone ligament relaxation from the sex hormones. The changes that happen on the ligaments and the cartilage of the pelvic bones secondary to the sex hormones may also lead some women to present with gait alterations. Finally, a number of women may experience paresthesia (numbness and tingling of fingers and toes). A number of theories are suggested for the explanation of these symptoms. The fingers and upper extremities are effected if lordotic posture is extreme; the head and neck are flexed, putting strain on the brachial nerves and causing tingling of hands and arms. Toes and lower extremities are affected if gravid uterus presses on femoral veins and nerves supplying lower extremities, thus interfering with circulation and causing paresthesia. Edema may cause pressure and tingling of hands or feet, especially in hands when rising in the morning. Sometimes excessive edema of the hands may lead to carpal tunnel syndrome. Finally, Vitamin B deficiency, hypoglycemia and hyperventilation have been suggested as causes of these symptoms

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