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**PHYSIOLOGICAL ADAPTATIONS TO PREGNANCY**

**INTRODUCTION**

Pregnancy is a unique period in a woman's lifetime. A number of anatomic, physiologic, biochemical and psychological changes take place. These changes may easily be misinterpreted by physicians who lack experience in regards to pregnancy effects on a woman's body. It is important that physicians caring for women understand the implications of these physiological changes in order to avoid any diagnostic errors and errors of management.

**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 striae. The increased levels of estrogen and progesterone have also been implicated. Usually striae remain permanently with some change in color. Prevention may be achieved with moisturizing creams, especially those containing lanolin and other oily substances. It should be realized, however, that striae may develop despite any preventative measures.

**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. 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, explain the correlation between the incidence of cholelithiasis and pregnancy.

**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 involve 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.

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". The mechanisms leading to hypervolemia in pregnancy are still not entirely understood and seem to be multifactorial. 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. 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.

Cardiac Output

It has been well established since the beginning of this century that 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.

Cardiac output is a product of stroke volume and pulse rate. The rise in cardiac output early in pregnancy is disproportionately greater than the increase in heart rate, and therefore is attributable to augmentation in stroke volume. 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.

Heart Rate During Normal Pregnancy

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. However, the total increase happens early in pregnancy and remains so throughout the remainder of gestation. 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.

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.

Blood Pressure

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 1/3 of the difference between systolic and diastolic) is less than 85 mm of mercury.

Systemic Vascular Resistance

Normal pregnancy is associated with a significant fall in systemic vascular resistance. As a result, the diastolic blood

pressure drops as well as the systolic. However, the diastolic blood pressure drops more than the systolic leading to a widening of the pulse pressure. A significant portion of this decline is caused by the development of a low resistance circulation in the pregnant uterus.

Estrogens, Prolactin, circulating prostaglandins PGE2 and PGI2 may be responsible for the vasodilatation that can cause a drop in the peripheral resistance. In addition, the profound dilatation of the skin vessels as a result of the increased maternal body heat dissipation may contribute to the drop in the systemic vascular resistance.

Blood Flow Changes in Various Organ Systems During Pregnancy

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 non placental). 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. It is safe, however, to speculate that an increase may happen since augmentation of cardiac function is present during pregnancy.

Cardiocirculatory Changes During Labor and Delivery

During labor significant hemodynamic changes take place. These changes can in part be explained by the effect of the uterine contractions, which may cause a significant increase of 300 to 500 ml in central blood volume, and in part by the effect of pain and anxiety on the cardiovascular system. It is important to note here that in the lateral position, cardiac output between contractions is higher than in the supine position.

The effect of uterine contractions during labor on the heart rate is variable. It may be an increase in heart rate or a decline in heart rate. The differences may have to do with different position of the patient during the labor process and certainly different

hemodynamic changes that can lead to the variability in the heart rate. Significant variations of individual heart rate responses to uterine contractions may also play a role. During labor (uterine contractions), both the systolic and diastolic blood pressures increase. The elevation of the blood pressure can be as high as 35 mm Hg in the systolic component and as high as 25 mm Hg in the diastolic component. As the labor process advances and the patient enters the second stage, an increase in the diastolic blood pressure as high as 65 mm Hg above the baseline can be observed. It is believed that since the peripheral resistance does not change or it changes only slightly during labor, the increase in blood pressure is attributed to the rise in cardiac output. Redistribution of maternal cardiac output to the upper part of the peripheral circulation after compression of the distal aorta and the common iliac artery has also been suggested to play a role in the elevation of systemic pressures as measured in the arm. These hemodynamic changes are less pronounced in lateral recumbency than in the supine position.

The hemodynamic changes during labor are influenced to a great extent by the form of anesthesia or analgesia employed. The above-mentioned changes in the cardiac output and blood pressure did not happen on patients with caudal anesthesia. The progressive rise in the heart rate and the blood pressure that is normally observed is abolished on these patients and the stroke volume is also maintained throughout labor but rises rapidly after delivery.

In patients who undergo cesarean section maternal hemodynamics can be significantly affected by anesthesia. A patient with heart disease may not tolerate the marked fluctuations with subarachnoid block anesthesia. Balanced anesthesia with thiopental, nitrous oxide, and succinyl choline, and epidural anesthesia without epinephrine are associated with smaller hemodynamic fluctuations and therefore should be preferred in patients with limited cardiac reserves.

****PSYCHOLOGY CHANGES IN PREGNANCY****

Pregnancy is always associated with changes in psychological functioning of pregnant women. It is usually associated with ambivalence, frequent mood changes, varying from anxiety, fatigue, exhaustion, sleepiness, depressive reactions to excitement. During pregnancy, changes include body appearance, affectivity and sexuality, whereas the position and role of women attains a new quality. Even thoughts of pregnancy can bring about numerous worries about its course and outcome, and especially of the delivery itself, which may be so intense that they acquire a features of phobia (which may be the reason for avoiding pregnancy).

**CHANGES IN THE RESPIRATORY SYSTEM**

Anatomically, the growth of the foetus during pregnancy causes upward displacement of the diaphragm. This however, does not decrease the total lung capacity significantly since there is also an increase in the transverse and anterior-posterior diameters of the thorax.In pregnancy a woman faces an increase in their metabolic rate which leads to an increased demand for oxygen. The tidal volume and the minute ventilation rate increases to help the mother meet the oxygen demands.

Many women experience hyperventilation during pregnancy. It is thought that the reason for this is the increased carbon dioxide production and the increased respiratory drive caused by progesterone. This hyperventilation results in a respiratory alkalosis with a compensated increase in renal bicarbonate excretion.

**CHANGES IN THE URINARY SYSTEM**

Increased cardiac output during pregnancy causes an increase in renal plasma flow which increases the GFR by about 50-60%. This would mean that there is an increase in renal excretion. So in pregnancy the levels of urea and creatinine will be lower.

Progesterone affects the urinary collecting system causing relaxation of the ureter (resulting in hydroureter). There is also relaxation of the muscles of the bladder. Both of these changes causes urinary stasis which predisposes a woman to UTIs, commonly pyelonephritis.

**HAEMATOLOGICAL CHANGES**

In pregnancy there is an increase in fibrinogen and clotting factors in the blood and a decrease in fibrinolysis. Additionally, due to an increase in progesterone levels stasis of blood and venodilation occurs. All these factors increase the risk of thromboembolic disease in pregnancy. Warfarin can not be given to pregnant women to counteract this as it can cross the placenta and it is a teratogen. Low Molecular Weight Heparin (LMWH) is usually considered the anticoagulant of choice during pregnancy if it is necessary to give the mother anticoagulant drug.During pregnancy the plasma volume increases significantly. However, the red cell mass does not increase by as much. This results in a physiological dilutional anemia