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1. Elucidate the physiological adaptation of female to pregnancy

**Introduction**

During pregnancy, a woman’s body changes in many ways due to the effect of hormones. These changes can sometimes be uncomfortable, but most of the time they are normal and enable her to nourish and protect the fetus, prepare her body for labor , and develop her breasts for the production of milk.

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. One has to remember that nature does not waste energy or effort. In that respect all the physiological changes that happen during pregnancy, happen for a purpose. As it will be appreciated later on in this chapter, almost every organ system of a female body is affected to some degree. An attempt was made to present the information by organ systems although there may be some overlap since most of the organ systems interact with each other and affect each other. Some organ systems will be discussed in detail more than others. This distinction will be solely based on the significance of the particular organ system changes.

**1.Changes in the breasts**

In early pregnancy, the breasts may feel full or tingle, and they increase in size as pregnancy progresses. The areola around the nipples (the circle of pigmented skin) darkens and the diameter increases. The Montgomery’s glands (the tiny bumps in the areola) enlarge and tend to protrude (stick out more). The surface blood vessels of the breast may become visible due to increased circulation, and this may give a bluish tint to the breasts. By the 16th week (during the second trimester), the breasts begin to produce colostrum. This is the precursor of breastmilk. It is a yellowish secretion from the nipples, which thickens as pregnancy progresses. It is extremely high in protein and contains antibodies (special proteins produced by the mother’s immune system) that help to protect the newborn baby from infection. Near the end of pregnancy, the nipples may produce enough colostrum to make wet patches on the woman’s clothes. Reassure her that this is normal and a good sign. After the baby is born, colostrum is produced for about the first three days, before the proper milk begins to flow. Make sure that the mother breastfeeds the colostrum to her baby, so he or she gets all the nutrients and antibodies it contains.

**2.Skin changes**

Changes in the woman’s hormones, and mechanical stretching of her growing abdomen and breasts, are responsible for several changes in the skin during pregnancy.

Linea nigra

This dark line may appear between the umbilicus (belly-button) and the symphysis pubis (pubic bone); in some pregnant women it may extend as high as the sternum (the bone between the breasts). It is a hormone-induced excess production of brown material (pigment) in the skin cells in this area. After delivery, the line begins to fade, though it may never completely disappear.

Mask of pregnancy (chloasma)

Some women produce a brownish pigmentation of the skin over the face and forehead, known as the ‘mask of pregnancy’ (or chloasma). It gives a bronze look. It begins about the 16th week of pregnancy and gradually increases, but it usually fades after delivery. You will learn more about it in Study Session 8.

Stretch marks

As the woman’s weight increases, stretching of the skin occurs over areas of maximal growth — the abdomen, thighs and breasts. Pink or brownish stretch marks may appear in some women, which can be quite dramatic. They usually fade after delivery, although they never completely disappear.

**3.Sweat glands**

Activity of the sweat glands throughout the body usually increases during pregnancy, which causes the woman to perspire (sweat) more profusely than usual, particularly in hot weather or during physical work.

Changes in the urinary system during pregnancy

The urinary system consists of the kidneys (a pair of organs on either side of the abdomen near the back), the tubes connecting the kidneys to the bladder where urine is stored, and a tube called the urethra that passes urine out of the body. The kidneys extract waste from the blood and turn it into urine. They must work extra hard to filter the mother’s own waste products from her blood, plus those of the fetus, and get rid of them in her urine. Therefore, there is also an increase in the amount of urine produced during pregnancy

Needing to urinate (pee) often is normal, especially in the first and last months of pregnancy. This happens because the growing uterus presses against the bladder. In late pregnancy, a woman often has to get up during the night to urinate, because fluid retained in the legs and feet during the day (oedema) is absorbed into the blood circulation when her legs are raised in bed. The kidneys extract the excess fluid and turn it into urine, so the bladder

**4.Changes in the gastrointestinal system in pregnancy**

As you may remember from your high school biology, food and fluids enter the gastrointestinal system in the mouth, pass through the oesophagus, stomach and intestines, and solid waste exits at the anus. This very long tube from mouth to anus is often called the ‘gut’. Proteins, fats and carbohydrates in our diet are broken down (digested) in the gut into units small enough to be absorbed from the intestines into nearby blood vessels. It is also the route by which nutritious substances, such as vitamins and minerals, enter the body.During pregnancy, the muscles in the walls of the gastrointestinal system relax slightly, and the rate at which food is squeezed out of the stomach and along the intestines is slowed down.

Many women also have nausea in the first months of pregnancy. A burning feeling, or pain in the stomach or between the breasts, is called indigestion (or ‘heartburn’, although the heart is not involved). It happens because as the pregnancy progresses, the growing baby crowds the mother’s stomach and pushes it higher than usual. The acids in the mother’s stomach that help digest food are pushed up into her chest, where they cause a burning feeling. This is not dangerous and usually goes away after the birth.

If the mother has difficulty with nausea or indigestion, advise her to eat small, frequent meals. The mother should not lie down flat for 1 to 2 hours after eating, because this may cause these symptoms.

**5.Respiratory changes**

During pregnancy, the amount of air moved in and out of the lungs increases by nearly 50% due to two factors:

each breath contains a larger volume of air

the rate of breathing (breaths per minute) increases slightly.

During pregnancy, many women find they get short of breath (cannot breathe as deeply as usual). This is because the growing baby crowds the mother’s lungs and she has less room to breathe. But if a woman is also weak and tired, or if she is short of breath all of the time, she should be checked for signs of sickness, heart problems, anaemia or poor diet. Get medical advice if you think she may have any of these problems.

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**6.Oedema in pregnanc**y

experiences severe oedema, including swelling of the face, this is a danger sign that requires immediate referral to the nearest health facility.

A combination of the slight increase in the permeability of the smallest of blood vessels (they allow more fluid to leak out into the tissues), the additional weight of the uterus, and the downward force of gravity, slow down the rate at which blood is pumped back to the heart from the lower half of the body. Fluid often collects in the tissues of the legs and feet of pregnant women after the first trimester, instead of being absorbed into the blood circulation. The swelling caused by this collection of fluid is called oedema.

It is a common condition in pregnant women, particularly if they stand for a long time during the day. Oedema of the hands may also occur. Advise the woman to rest frequently and to elevate (raise) her feet and legs while sitting. This will improve the return of blood to her heart and decrease swelling of the legs.

**7.Blood pressure in pregnancy**

We said earlier that progesterone causes the ligaments and joints to loosen during pregnancy. It also acts with some other natural chemicals in the body to cause the muscular walls of the blood vessels to relax slightly. The result is that there is less resistance to the flow of blood around the body, because the same volume of blood is circulating in slightly wider blood vessels. Blood pressure (BP) refers to how hard the blood is ‘pushing’ on the walls of the major blood vessels as it is pumped around the body by the heart.

Lower blood pressure is particularly common in early pregnancy. Many women report occasionally feeling dizzy in the first trimester, because less blood and less oxygen is being pumped to the brain. Progesterone can also cause a sudden larger relaxation in the blood vessels, resulting in an acute feeling of dizziness, or even a brief loss of consciousness (passing out).

Another cause of dizziness can result from lying flat on the back. This is more common after 24 weeks of pregnancy, but it can happen earlier during twin pregnancies, or conditions that increase the volume of amniotic fluid (waters surrounding the fetus). When a pregnant woman is lying flat on her back, the weight of her uterus and its contents compresses the large blood vessel (vena cava) leading from her lower body to the heart. When this blood vessel is squashed, the blood flow back to the heart is reduced, which in turn leads to a reduction in the blood flow out of the heart to the rest of the body.

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**8.The heart**

The heart may increase in size during pregnancy due to an increase in its workload.The increase in cardiac output is caused by two changes in how the heart functions:

Increase in the resting heart rate, i.e. the number of heart beats per minute. The heart rate is about 15 beats per minute higher in the pregnant woman.

Increase in the stroke volume, i.e. the volume of blood pumped out of the heart in a single heart beat. It is about 7 millilitres (ml) larger per heart beat in the pregnant woman.

Cardiac output is calculated by multiplying heart rate and stroke volume.

During the second trimester of pregnancy, the mother’s heart at rest is working 40% harder than in her non-pregnant state. Most of this increase results from a more efficiently performing heart, which ejects more blood at each beat.

**9.Changes in the cardiovascular system**

The cardiovascular system consists of the heart, the blood vessels (veins and arteries), and the blood that circulates around the body. It is the transport system that supplies oxygen and nutritive substances absorbed from the gastrointestinal tract to all the cells, tissues and organs of the body, enabling them to generate the energy they need to perform their functions. It also returns carbon dioxide, the waste product of respiration, to the lungs, where it is breathed out. The chemical processes that go on in the body generate many waste products, which the blood transports to the kidneys and liver, where they are removed. Other functions of the cardiovascular system include the regulation of body temperature, and the circulation and delivery of hormones and other agents that regulate body functions. There are several significant changes in this complex system during pregnancy

**10.Changes in the uterus, cervix and vagina**

The uterus

After conception, the uterus provides a nutritive and protective environment in which the fetus will grow and develop. It increases from the size of a small pear in its non-pregnant state to accommodate a full-term baby at 40 weeks of gestation. The tissues from which the uterus is made continue to grow for the first 20 weeks, and it increases in weight from about 50 to 1,000 gm (grams). After this time, it doesn’t get any heavier, but it stretches to accommodate the growing baby, placenta and amniotic fluid. By the time the pregnancy has reached full term, the uterus will have increased to about five times its normal size:

In height (top to bottom) from 7.5 to 30 cm

In width (side to side) from 5 to 23 cm

In depth (front to back) from 2.5 to 20 cm.

What causes these changes

At 12 weeks’ gestation (near the end of the first trimester, i.e. three-month period), the fundus (upper margin of the body of the uterus) may be palpated (felt) through the abdomen above the pubic bone (symphysis pubis). The size of the uterus usually reaches its peak at about 36 weeks’ gestationThe uterus may drop slightly as the fetal head settles into the pelvis, preparing for delivery. This dropping is referred to as ‘lightening’. It is more noticeable in a primigravida (pregnant for the first time) than in a multigravida (a woman who has been pregnant previously, regardless of outcome).

**The cervix**

The cervix remains 2.5 cm long throughout pregnancy. In late pregnancy, softening of the cervix occurs in response to increasing painless contractions of its muscular walls.

The vaginal

The vagina also becomes more elastic towards the end of pregnancy. These changes enable it to dilate during the second stage of labour, as the baby passes down the birth canal

**11.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. This pattern was established with studies that kept the patients in the left-lateral position to avoid vena cava compression. However, studies that kept the patient in the supine position had controversial results indicating a decline in the blood volume after 34 to 36 weeks. 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 roll of atrial natriuretic factor (ANF) in mediating changes in fluid balance during gestation is still not clearly understood. On the other hand increased levels of human chorionic somatomammotropin and prolactin increase the amount of erythropoiesis and thus causes the necessary increase in the red blood cell mass. 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. 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. That was the case in most if not all of the studies that evaluated women in a left-lateral tilt while studies that placed women in the supine position have shown a rather false reduction in cardiac output which was primarily mediated by inferior vena cava compression.

**12.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. The effect of maternal posture on cardiac output was demonstrated by a number of studies. A significant decrease (25 to 30 percent) in cardiac output, measured by dye dilution technique, was demonstrated in the supine position between the 38th and 40th weeks of pregnancy but not before the 24th week. These findings were confirmed recently by echocardiographic studies. Since heart rate was not affected significantly, positional decline in cardiac output was due to decreased stroke volume. The fall in cardiac output was also not associated with a significant change in blood pressure. This is probably due to an increase in peripheral vascular resistance. As many as 11 percent of women when placed in the supine position, will develop symptomatic hypotension and drop in the cardiac output which may lead to a loss of consciousness. These symptoms are relieved promptly with left-lateral positioning. In these particular patients who develop the symptoms, the cardiac output is not maintained despite the fact that they develop a significant increase in their heart rate. It is believed that the patients who become symptomatic are those who lack sufficient paravertebral collateral circulation to permit blood from the legs and the pelvic organs to bypass the occluded inferior vena cava.

**12.Hormonal**

Pregnant women experience numerous adjustments in their **endocrine system** that help support the developing fetus. The fetal-placental unit secretes steroid hormones and proteins that alter the function of various maternal **endocrine glands**. Sometimes, the changes in certain hormone levels and their effects on their target organs can lead to **gestational diabetes** and **gestational hypertension**.

**Fetal-placental unit**

Levels of progesterone and estrogen rise continually throughout pregnancy, suppressing the hypothalamic axis and subsequently the menstrual cycle. The progesterone is first produced by the **corpus luteum** and then by the placenta in the second trimester. Women also experience increased **human chorionic gonadotropin** (β-hCG), which is produced by the placenta.

### Pancreatic Insulin

The placenta also produces **human placental lactogen** (hPL), which stimulates maternal lipolysis and fatty acid metabolism. As a result, this conserves blood glucose for use by the fetus. It can also decrease maternal tissue sensitivity to insulin, resulting in **gestational diabetes**.

### Pituitary gland

The **pituitary gland** grows by about one-third as a result of hyperplasia of the lactrotrophs in response to the high plasma estrogen. **Prolactin**, which is produced by the lactrotrophs increases progressively throughout pregnancy. Prolactin mediates a change in the structure of the breast **mammary glands** from ductal to lobular-alveolar and stimulates milk production.

### Parathyroid

Fetal skeletal formation and then later lactation challenges the maternal body to maintain their calcium levels. The fetal skeleton requires approximately 30 grams of calcium by the end of pregnancy. The mother's body adapts by increasing **parathyroid hormone**, leading to an increase in calcium uptake within the gut as well as increased calcium reabsorption by the kidneys. Maternal total serum calcium decreases due to maternal **hypoalbuminemia**, but the ionized calcium levels are maintained.

### Adrenal glands

Total **cortisol** increases to three times of non-pregnant levels by the third trimester. The increased estrogen in pregnancy leads to increase corticosteroid-binding globulin production and in response the **adrenal gland** produces more cortisol. The net effect is an increase of free cortisol. This contributes to insulin resistance of pregnancy and possibly striae. Despite the increase in cortisol, the pregnant mom does not exhibit **Cushing syndrome** or symptoms of high cortisol.

The adrenal gland also produces more **aldosterone**, leading to an eight-fold increase in aldosterone. Women do not show signs of hyperaldosterone, such as hypokalemia, hypernatremia, or high blood pressure.

The adrenal gland also produces more **androgens**, such as testosterone, but this is buffered by estrogen's increase in sex-hormone binding globulin (SHBG). SHBG binds avidly to testosterone and to a lesser degree DHEA.

### Thyroid

The **thyroid** enlarges and may be more easily felt during the first trimester. The increase in kidney clearance during pregnancy causes more iodide to be excreted and causes relative iodine deficiency and as a result an increase in thyroid size. Estrogen-stimulated increase in thyroid-binding globulin (TBG) leads to an increase in total **thyroxine** (T4), but free thyroxine (T4) and **triiodothyronine** (T3) remain normal.