Review Article

Physiological changes in pregnancy

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ABSTRACT

Physiological changes occur in pregnancy to upbringing the developing fetus and prepare the mother for labor and delivery. Early changes result in metabolic demands, increasing levels of pregnancy hormones, particularly those of progesterone and estrogen. Later changes starting in midpregnancy are caused from the expanding uterus by mechanical pressure. During pregnancy, some changes in maternal physiology can occur including increased maternal fat, blood volume, cardiac output, and blood flow to the kidneys and uteroplacental unit, decreased blood pressure, delayed gastrointestinal motility, and gastric emptying. These alterations are essential to optimize fetus and mother health.

KEY WORDS: Body weight, Fetal growth, Physiological changes, Pregnancy and uterus

INTRODUCTION

Pregnancy is a unique period during a women's life which is characterized by complex physiological and hormonal changes. Pregnancy is a normal condition and simultaneously the most common altered physiologic state to which human beings are subject to changes. The physiological changes are begin after conception and affect every organ system in the body and also help the women to adapt the pregnant state and to aid fetal growth. Many of these alterations significantly affect the pharmacokinetics (absorption, distribution, metabolism, and elimination) and pharmacodynamics properties of different therapeutic agents.[1] These changes resolve after pregnancy with minimal residual effects in uncomplicated pregnancy. Such anatomical and physiological changes may cause confusion during clinical examination of pregnant woman. During pregnancy, some changes in blood biochemistry may create difficulties in interpretation of results. To improve maternal and fetal outcome, the pathological deviations in these anatomical and physiological changes should be recognized.[2]

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CHANGES IN UTERUS

Uterus provides a nutritive and protective environment in which the fetus will grow and develop after conception. 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 50–1000 grams. After this time, it does not 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 5 times its normal size in height from 7.5 to 30 cm, in width from 5 to 23 cm, and in depth from 2.5 to 20 cm. Softening and compressibility of lower uterine segment occurs at approximately 6 weeks of gestation which is called Hegar sign. As uterus increase in size, blood flow also increases. The weight of the fetus, the enlarged uterus, the placenta, and the amniotic fluid, together with the increasing curvature of her back, put a large strain on the woman's bones and muscles. As a result, many pregnant women get back pain.[3]

CHANGES IN THE BODY WEIGHT

Continuing weight increase in pregnancy is considered to be one favorable indication of maternal adaptation

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and fetal growth. There can be a slight loss of weight during early pregnancy if the woman experiences much nausea and vomiting (often called "morning sickness"). The expected increase in weight of a healthy woman in an average pregnancy, where there is a single baby is about 2.0 kg in total in the first 20 weeks, then approximately 0.5 kg per week until full term at 40 weeks and a total of 9–12 kg during the pregnancy. A woman who is pregnant with more than one baby will have a higher weight gain than a woman with only one fetus. She will also require a higher calorie diet. A lack of significant weight gain may not be a cause for concern in some women, but it could be an indication that the fetus is not growing properly.[4]

HEMATOLOGICAL CHANGES

In pregnancy, maternal physiological adjustments support the requirements of fetal hemostasis. During pregnancy, the normal values for many hematologic, biochemical, and physiologic indices differ from those in non-pregnant range.[5] Throughout normal pregnancy, plasma volume increases progressively. The increase starts at around 6 weeks' gestation and reaches a maximal volume by 32 weeks gestation. A rapid increases in blood volume until midpregnancy, with a slower increases thereafter.[6] Plasma volume increases significantly much higher, which leads to "physiologic anemia" of pregnancy. There is a fall in hematologic concentration, increased white and red blood cell counts, and no change in mean corpuscular volume or mean corpuscular hemoglobin concentration.[7] The platelet count itself is relatively unchanged, although the platelet volume may be increased. Iron demands increase in later gestation and supplementation of iron is needed to avoid iron depletion.[8] Nearly, all the procoagulants are increased in pregnancy so that patient is hypercoagulable as the gestation progresses. There is increase in fibrinogen and factor VIII and slower increases in factors VII, IX, X, and XII. Fibrinolytic activity is diminished during pregnancy by unknown mechanism. In proportion to fibrinogen, plasminogen level increased. Clotting and lysing activities are balanced. It take about 8 weeks after delivery for the blood volume to return back to normal.[9]

CARDIOVASCULAR CHANGES

There are numerous changes in the cardiovascular system during pregnancy. The heart is displaced upward, slightly to the left due to increased size of the uterus in pregnancy so that there is an increased capacity of the heart.[10] Cardiac output is increased in pregnancy and attained maximal increase around 24 weeks gestation. It is one of the most important maternal changes.[11] There are increased heart rate and stroke volume and decreased systemic vascular resistance and peripheral resistance. Heart rate is increased maximally by the second trimester, but there is no further change in the third trimester.[12] Stroke volume is increased at 8 weeks gestation and increased much higher by the end of the second trimester, then remains level until term. Systolic blood pressure does not drop or slightly changed. However, there is a marked drop in diastolic blood pressure and also decreases in venous return.[13]

RESPIRATORY CHANGES

Changes in respiratory system in pregnancy start as early as the 4th week of gestation. There is slight increase in respiratory rate. Minute ventilation is increased which is mainly due to increased tidal volume.[14] Dead volume of lungs increases due to relaxation of muscles in conducting passageways. Total capacity decreases due to encroachment by diaphragm. Also there is Increased alveolar ventilation without any change in anatomical dead space.[15] Increased progesterone can decrease threshold of medullary respiratory center to carbon dioxide. Functional residual capacity, residual volume, and expiratory reserve volume are decreased at term. Inspiratory capacity and inspiratory reserve volume are increased.[16] There is no change in vital capacity. Due to increased chest circumference, the total lung capacity is reduced slightly even with the presence of elevation of diaphragm.[17]

RENAL CHANGES

Renal pelvis and uterus are dilated which lead to increase in urinary stasis and increase the chance of infection.[18] During pregnancy, the glomerular filtration rate is increased due to increased renal plasma flow. Due to increased filtration rate, there is decreased plasma blood urea nitrogen and creatinine concentration.[19] Serum concentrations of certain drugs are lower during pregnancy because of both expanded blood volume and increased glomerular filtration rate.[20] There are no changes in urinal output during pregnancy but require increase efficiency in the urinary system. Glucose and amino acids might not be absorbed; hence, glucose Rica and aminoaciduria may develop in normal gestation.[21] Glucosuria is not abnormal with no change increases in capacity to resorb sugar due to increased filtration rate. There is increased renin secretion and prostaglandin synthesis in pregnancy. These changes are return to normal by the 6th week of delivery.[22]

GASTROINTESTINAL CHANGES

During Pregnancy there is Increased nutritional requirements, increased maternal appetite and morning sickness. Gastrointestinal motility, lower esophageal pressure, and food absorption are decreased during

pregnancy due to an increased level of plasma progesterone.[23] On the other hand, intragastric pressure is increased during the third trimester of pregnancy. Gastric emptying time of solid and liquid material is not changed during pregnancy but slower during labor and hence gastric volume us increased. Due to decreased plasma gastric concentration, there is reduction in the total acid content of the stomach and increased serum alkaline phosphatase. Gallbladder function and emptying during pregnancy, hence, pregnant woman may prone to gallstone problems.[23]

ENDOCRINE CHANGES

Thyroid Function

The thyroid faces three challenges during pregnancy. First, increased renal clearance of iodide and losses to the fetus create a state of relative iodine deficiency, such that pregnancy stimulates growth of thyroid goiters in geographical areas where dietary iodine intake is low. Second, high estrogen levels induce hepatic synthesis of thyroid binding globulin, but free thyroxine (T_4) and triiodothyronine (T_3) levels still fall during pregnancy, occasionally below the normal range for non-pregnant women. Thyroid-stimulating hormone (TSH) levels rise as pregnancy progresses but generally remain within the normal range for non-pregnancy. Third, placental human chorionic gonadotropin (hCG) shares structural similarities with TSH and has weak TSH-like activity. Although hCG rarely stimulates free T_4 levels into the thyrotoxic range, trophoblastic disease and hyperemesis gravidarum are often associated with high hCG levels and can lead to hypothyroxinemia and suppression of TSH. In these circumstances, the mother remains clinically euthyroid.[24]

Pituitary Function

The maternal pituitary makes only a small contribution to a successful pregnancy once ovulation has occurred and the uterus is prepared for implantation. The only pituitary hormone to increase significantly during pregnancy is prolactin, which is responsible for breast development and subsequent milk production. Pituitary secretion of growth hormone (GH) is mildly suppressed during the second half of pregnancy by placental production of a GH variant, the role of which is unclear, but it may contribute to gestational insulin resistance. Placental production of adrenocorticotropin hormone (ACTH) leads to an increase in maternal ACTH levels but not beyond the normal range for non-pregnant subjects. Free cortisol levels double and in the second half of pregnancy may contribute to insulin resistance and striae gravidarum. High estrogen levels during pregnancy stimulate lactotroph hyperplasia and result in pituitary enlargement. These high levels, together with those of progesterone, suppress luteinizing hormone (LH) and follicular-stimulating hormone (FSH). Plasma FSH levels recover within 2 weeks of delivery, but pulsatile luteinizing hormone release is only resumed in women who do not breastfeed. In suckling mothers, prolactin inhibits gonadotropin-releasing hormone and hence LH.[25]

Metabolic Changes

Fluid balance

An underfilled state stimulates the renin-angiotensin-aldosterone system which is created by arterial dilatation. As a result, sodium and water retention throughout pregnancy leads to a 6–8 l rise in total extracellular fluid volume. Plasma volume increases steadily until week 32 when it is 40% above non-pregnant levels. This is partly mediated by a fall in the osmotic threshold for thirst, with a concomitant fall in the threshold for secretion of antidiuretic hormone (AVP) preventing a water diuresis and sustaining a low plasma osmolality until term. During the second half of pregnancy, placental production of vasopressinase increases maternal Arginine Vasopressin (AVP) degradation, but plasma AVP levels remain stable as pituitary secretion of AVP normally increases 4-fold. A failure of increased AVP secretion leads to transient diabetes insipidus of pregnancy. Plasma atrial natriuretic peptide levels are normal until the second trimester, when they rise by approximately 40%.[25]

Carbohydrate metabolism

Glucose is the primary energy source of fetoplacental tissues. During early pregnancy, basal plasma glucose and hepatic glucogenesis are unchanged. However, during late pregnancy, the mother develops hypoglycemic (specifically under fasting). The development of maternal hypoglycemia despite the enhanced glucogenesis and reduced consumption of glucose by maternal tissues due to insulin resistant is the result of high rate of placental transfer of glucose. The fetus does not synthesize glucose but uses it as its oxidative substrate which causes fetal glycemia to be normally lower than its mother, allowing a positive maternal-fetal glucose gradient that facilitates its placental glucose transfer.[24]

Protein metabolism

Protein is essential for fetal growth and must be sustained by the active transfer of amino acids from maternal circulation. Protein metabolism changes occur gradually throughout gestation so that nitrogen conservation of fetal growth achieves full potential during the last quarter of pregnancy. Due to reduction in urinary nitrogen excretion as a consequence of decreased urea synthesis, there is increased nitrogen retention in late pregnancy. Nitrogen balance is improved in late pregnancy which allowing a more efficient use of dietary proteins.

Although these alterations in protein metabolism favor nitrogen conservation, pregnancy is associated with hypoaminoacidemia is present at early gestation and persists throughout pregnancy. The maternal hypoaminoacidemia reflects enhanced placental amino acid uptake.[24]

Lipid metabolism

Accumulation of fat deposits in maternal tissues and maternal hyperlipidemia is characteristic features during pregnancy. Although lipids cross the placenta with difficulty, essential fatty acids (EFAs) and long chain polysaturated fatty acids are needed for fetal growth and development and must arrive from maternal circulation. Therefore, during pregnancy, there are major changes in lipid metabolism.[24]

CONCLUSION

Many changes occur in the pregnant patient which are important to understand the normal changes so can work up patient and interpret investigations as well as provide optimal care. Pregnant patients can definitely have non-pregnancy reacted issues may have to provide care for pregnant patient. Multidisciplinary approach will be necessary. In this review, the highlights of altered physiology will be helpful in managing critical illness complicating pregnancy.

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