WISELEAF SCIENTIFIC VENTURES

COMPREHENSIVE PREGNANCY CARE: AN EVIDENCE-BASED MULTIDISCIPLINARY APPROACH

Chapter 2: Early Pregnancy, Maternal Physiological Changes and Fetal Development

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Abstract

The phase of early pregnancy is crucial since it involves rapid embryogenesis, placentation, and many maternal physiological adjustments. Correct confirmation of pregnancy and timely commencement of antenatal care may ensure the health of both mother and fetus and allows detecting possible risks early. This chapter will focus on pregnancy confirmation as well as initial antenatal care measures, first-trimester management, hormonal alterations, adaptation of mother's organism, and embryos' and fetuses' development. Additionally, the main signs of pregnancy will be explained and urine and blood β-hCG testing and ultrasound methods will be described. This chapter also provides details about the major hormonal changes that take place during pregnancy which include: Human chorionic gonadotropin, Progesterone, Estrogen, Human placental lactogen and other hormonal agents that play an important part in enabling pregnancy and helping the body adapt to it. It also gives a detailed overview of the physiological changes that occur in various bodu systems, namely cardiovascular, hematological, respiratory, renal, gastrointestinal, metabolic, musculoskeletal, reproductive, skin and other bodily systems. The chapter offers a detailed description and clear understanding of the fetal development from the first month to the ninth month including the important milestones and the process of organ maturation during this period. The discussion on pregnancy symptoms is also provided along with the basic rules of managing the symptoms being experienced. In the end, the chapter reminds the importance of early antenatal registration and regular checking-up.

Keywords

Early pregnancy; Antenatal care; Fetal development; Maternal adaptations; Pregnancy confirmation.

2.1 Concept and Confirmation of Pregnancy

Pregnancy is a process that starts with the fertilization of the egg and continued by implantation of the fertilized egg into the woman's uterus. To enhance the potential growth and development of the baby, the mother will experience various changes to her physiology. The verification of the occurrence of pregnancy is important step in initiation of proper prenatal treatment, assessment of risks involved in pregnancy, correction of diet, and lowering of adverse effects of environment on both mother and fetus.

2.1.1 Definition and Stages of Pregnancy

Pregnancy is the interval in which a fertilized egg becomes an embryo and then a fetus inside the womb. In medical practice, pregnancy is generally dated from the first day of the last menstrual period (LMP) and not from the actual day of conception. [1] The duration of normal pregnancy is approximately 40 weeks (280 days) from the date of the last menstrual period (LMP). [2]

Pregnancy is divided into three trimesters:

Table 2.1: Trimesters of Pregnancy and Major Developmental Characteristics

Trimester	Gestational Age	Major Characteristics
First trimester	0–13 weeks + 6 days	Implantation, embryonic development and organ formation
Second trimester	14–27 weeks + 6 days	Rapid fetal growth and maturation
Third trimester	28 weeks to birth	Continued fetal growth and organ maturation

As mentioned in (Table 2.1) the first stage of development is the embryonic stage during which the vital organs and structures of the body are formed. The second stage is known as the fetal stage, which is primarily characterized by growth, differentiation, and functional maturity of the already formed organs.

2.1.2 Signs and Symptoms of Pregnancy

Early pregnancy can be suspected based on various changes in the menstrual, bodily, and reproductive systems, out of which, missed menstruation is the most prominent symptom especially people with normal menstrual cycle. [3] Other symptoms include nausea, breast tenderness or enlargement, tiredness, increased urination frequency, swollen abdomen, change in appetite, increased sensitivity to smells, and changing food preferences. The extent to which symptoms occur can differ greatly between people. Pregnancy can also be found during clinical examination, during which breast enlargement, increased coloration of areola, softening of the

cervix, abdominal swelling, and increased amount of vaginal discharge may be found. Nevertheless, such changes are not specific as they may occur in other medical conditions. Hence, referred pregnancy should be confirmed with the help of a pregnancy test and ultrasound in certain cases. [4]

2.1.3 Pregnancy Tests

Pregnancy tests are founded on the principle of detecting hCG or human chorionic gonadotropin, which is the hormone secreted by trophoblastic cells after implantation. The hormone can be found in both blood and urine samples. Urine tests are frequently the first option used to establish pregnancy due to their convenience and speed of response. Urine tests are advised only after the first missed period but would be more accurate if done on the first urine sample in the morning when the test is positive. The advantage of performing serum β-hCG tests is that they provide more accurate and sensitive results in terms of pregnancy detection than urine tests. Quantitative β-hCG testing can provide the exact level of hormone concentration, which makes it useful in situations in which early pregnancy is difficult to detect. If necessary, β-hCG test results can also be accompanied with ultrasound examination. However, looking at β-hCG results separately from other clinical data would not provide a clear picture of pregnancy. [5]

2.1.4 Ultrasonography in Early Pregnancy

Ultrasonography plays an important role in early pregnancy assessment as it can provide some information about the location of pregnancy, gestational age, its viability, and the number of embryos or fetuses. The use of transvaginal ultrasound is of great significance in such conditions as it provides an excellent and accurate illustration of the uterus and its surrounding organs. Ultrasonography may show the gestational sac, the yolk sac, the embryo or the fetal pole, and the heartbeat depending on the weeks of gestation. The CRL (crown-rump length) plays an important role in defining pregnancy term in the first trimester. Moreover, ultrasonography has proven to be useful in the case of patients with abdominal or pelvic pain or bleeding if they are suspected of ectopic pregnancy or early pregnancy loss.

Ultrasound scans undertaken in the early stages of gestation do not always yield enough information to determine whether the pregnancy is viable or not, which may lead to the need for follow-up scans in some situations. Imaging findings must be interpreted together with clinical history, examinations, and β-hCG tests whenever applicable. Making a correct diagnosis of the pregnancy is extremely important, as it allows for timely antenatal care and testing, risk assessment, and necessary interventions. [6]

2.2 Early Antenatal Care

It is important for pregnant women to begin receiving antenatal care at the earliest possible moment in order to maintain a healthy pregnancy. It provides the opportunity of evaluating maternal health, establishing the gestational age, discovering medical and obstetric risks, commencing the necessary tests, advising on nutrition, lifestyle, immunization, medication safety, and preventative treatment. Regular antenatal monitoring of the mother and fetus is essential for well-being analysis and early complication detection.

2.2.1 Initial Maternal Assessment

The initial maternal assessment is a thorough process ensuring proper evaluation of the pregnant woman and that the baseline state of health is established, along with identifying the factors which must be taken into account when predicting the pregnancy outcome. The complete history must comprise the history of menstruation and pregnancies, the list of the previous pregnancies with their outcomes, the medical and surgical history of the patient along with information about the current medicaments which are taken, allergies, family history, vital factors of the patient's lifestyle, and others. Previous complications of pregnancy, recurring pregnancy loss, previous cesarean section, or any chronic diseases must be evaluated in detail. The physical assessment must include blood pressure and height measurements, body mass index, as well as examination of all necessary systems such as cardiovascular, respiratory, and others in case it is necessary. Additionally, other issues must be discussed: mental state, nutrition, exposure to toxins, working conditions, and social aspects. [7]

2.2.2 Routine Investigations

Standard prenatal checks are carried out to gauge a woman's health and determine any potential issues that could put the health of savior in danger. As mentiones (Table 2.2) commonly performed initial tests are hemoglobin tests or blood counts, Rh typings, urinalysis, and tests for a number of infections such as HIV, syphilis, and hepatitis B. The exact testing that will be performed will depend on the patient's age, medical history, risk factors, and skills already possessed by the doctor. Depending on the results, the patient may also be screened for diabetes, thyroid problems, hepatitis C, sexually transmitted diseases, and/or certain genetic disorders. Results of the tests have to be noted down properly so that any abnormalities can be tackled in time. Repeating tests if necessary is recommended throughout the pregnancy. [8]

Table 2.2: Routine Investigations During Early Antenatal Care

Investigation	Purpose
Complete blood count	Assessment of anemia and hematological status
Blood group and Rh typing	Identification of Rh incompatibility risk
Blood glucose testing	Screening for abnormal glucose regulation

Urinalysis	Detection of urinary abnormalities and infection
HIV testing	Identification of maternal infection and prevention of transmission
Hepatitis B screening	Identification of maternal infection
Syphilis screening	Detection and management of maternal infection
Ultrasonography	Assessment of gestational age, viability, and pregnancy location

2.2.3 Nutritional Care and Supplementation

It is crucial to maintain a healthy diet throughout pregnancy in order to ensure good mother's health, a proper placental function and a normal fetal development. Expectant mothers should be advised on how to maintain a balanced and nutritious diet that includes protein, grains, fruits, vegetables, fats and vital micronutrients. [9] Pregnancy increases the need for different nutrients, including folate, iron, iodine, calcium and vitamin D taking folic acid before and during pregnancy is essential for lessening the risk of neural tube defects. Iron and folic acid are often suggested to prevent and treat maternal anemia according to national recommendations. It might also be advised to take calcium supplements in case dietary calcium intake is insufficient or pregnant women are likely to have hypertension in their pregnancy. Nutritional counseling also includes the importance of a proper fluid intake, weight gain during pregnancy, food safety and staying away from drugs. [10]

2.2.4 Immunization and Preventive Care

Immunization plays an essential role in antenatal preventive care as vaccination during pregnancy can guard the mother against vaccine-preventable diseases and ensure the transmission of maternal antibodies resulting in passive immunity for the baby. Vaccination recommendations depend on a number of factors such as immunization schedules in different countries, maternal vaccination history, local nature of diseases, and risk factors. Vaccines for influenza and tetanus are usually recommended in the course of pregnancy whereas pertussis vaccination is mandated by some programs. Old vaccination cannot be administered during pregnancy except if there is a strict need for it. Apart from vaccination in antenatal care, patients receive instructions regarding personal hygiene, making healthy food and water choices, doing moderate exercises, rest, oral health, taking medications safely, and quitting bad habits, including alcohol, smoking, and health hazards. It is also vital to inform patients about the symptoms of problems in pregnancy that require immediate medical assistance. Thus effective prenatal care prevents unnecessary complications as well as helps in ensuring the positive outcome after a pregnancy. [11]

2.3 First Trimester Management

The first trimester marks a crucial phase of pregnancy characterized by implantation, development of the embryo, and formation of the first organ systems. Proper management

during this time is concerned with the evaluation of the health of the mother and the fetus, diagnosis of pregnancy complications and already existing risk factors, and starting necessary screening and preventive measures. Early antenatal care ensures early detection of complications and normal development of pregnancy.

2.3.1 Maternal and Fetal Assessment

In the first trimester, maternal assessment entails general health assessment along with vital signs, and evaluation of nutritional status and weight, blood pressure and any other medical or obstetrics conditions that may matter. A thorough history should reveal any past pregnancy complications, presence of chronic diseases, medications taken, any allergies and other aspects which may affect the pregnancy outcome. [12] Assessing symptoms like nausea, vomiting, pain in abdomen, vag bleeding, dizziness and urinary issues should also be part of maternal assessment. Moreover, maternal mental health is part of comprehensive care. Fetal evaluation in the first trimester involves confirmation of pregnancy location, establishing viability, determination of gestational age, and number of pregnancies. The use of ultrasound, in particular transvaginal ultrasound, if required, helps in detecting early pregnancy changes and embryonic development monitoring as well as evaluation of cardiac activity. The crown–rump length is commonly used in the first trimester for estimating the gestational age. [13]

2.3.2 Screening and Risk Assessment

The purpose of first-trimester screening is to determine if any maternal diseases, infections or genetic abnormalities exist that may impact the pregnancy. The screening process consists of collecting information about the patient's medical, obstetric, family and social history and completing the necessary physical exams and laboratory tests. [14] The first-trimester screening usually includes tests for anemia, blood group and Rh factor, HIV, hepatitis B and syphilis along with some other diseases based on the recommendations and individual risk factors. Additionally, testing for gestational diabetes and other maternal disorders may be performed depending on risk status and time of the screening. [15]

The first trimester screening has the purpose of identifying different kinds of diseases, infections, and genetic or chromosomal defects during pregnancy. The first thing that is done is taking medical, obstetric, social, and family histories as well as performing physical exams and laboratory tests. Among the tests performed in the course of screening are the following ones: test for anemia, blood group and Rh factor, HIV, hepatitis B, syphilis, and many others depending on the national guidelines and individual risk factors. Moreover, screening may include testing for gestational diabetes and some other disorders of the mother.

2.3.3 Medication Safety

Medication safety is crucial in the first trimester, due to embryonic organ development during this time, which means some drugs could cause a fetal defect. Therefore, during early

pregnancy, it is essential to evaluate all prescription medicines, over-the-counter products, herbs, supplements, and other substances that the mother may have taken. Thus, medications should only be used during pregnancy if the benefits of their use are greater than the possible risks, considering the stage of the pregnancy, woman's health, other available drugs and their safety information. Individuals who are pregnant must not stop taking medications they have been on for a while without consultation with medical professionals since uncontrolled maternal diseases may cause more harm than medications. [16] Therefore, medical professionals must assess the need and safety of each medication and provide the lowest plausible dose for the shortest foreseen period if any treatment is given. One must avoid involving in self-medication in any way particularly with over-the-counter medications and also with herbal and traditional therapies which might not have their safety level established in pregnant women. [17]

2.3.4 Warning Signs and Emergency Care

In early gestation, numerous symptoms are observed, while some symptoms require immediate medical attention as they can indicate grave complications. Vaginal bleeding, severe abdominal pain or pelvic pain, shoulder pain, fainting or severe dizziness, persistent vomiting and inability to keep the fluid down, fever, urination which is accompanied with pain, and a sudden deterioration of the general condition should not be ignored. Serious vaginal bleeding or terrible pain in the abdomen may require urgent medical attention, as it can be a symptom of ectopic pregnancy, miscarriage, or other complications. [18] Pregnant women should be educated on what warning signs they should look for and encouraged to seek medical help instead of trying to help themselves. Emergency assessment will include thorough clinical examination of the patient, various blood tests as well as the measurement of serum β-hCG and ultrasonic scanning in accordance with the symptoms that a woman has. Proper understanding of various complications occurring during pregnancy and appropriate treatment of the complications can help to avoid problems for mothers and babies. [19]

2.4 Hormonal Changes during Pregnancy

Pregnancy is associated with profound hormonal changes that regulate implantation, maintenance of the uterine environment, placental function, maternal metabolic adaptation, and fetal growth and development. Following implantation, the placenta becomes an important endocrine organ and produces several hormones that interact with the maternal hypothalamic–pituitary, thyroid, adrenal, and reproductive systems. As shown in (Fig 2.1) these hormonal changes are responsible for many physiological adaptations and common symptoms experienced during pregnancy.

2.4.1 Human Chorionic Gonadotropin (hCG)

Human chorionic gonadotropin otherwise known as hCG is one of the very first hormones to be produced during the period of pregnancy, meaning it is produced mostly by the syncytiotrophoblast after the process of implantation has taken place. The main function of hCG during the early pregnancy is the maintenance of the corpus luteum which means that this hormone helps with the formation of the progesterone until the placenta is capable of carrying out this function itself. hCG is secreted in both blood and urine of the mother and is the basis of the common pregnancy tests. Since the level of hCG in mothers increases rapidly during the early stages of pregnancy with the peak of its formation occurring at the end of the first trimester, this substance is the most abundant in the body at this period and after that, its amount is decreased during the rest of pregnancy. hCG also assists in placentation and has an impact on the thyroid. With that being said hCG is quite similar to thyroid-stimulating hormone since it has a similar structure to that hormone. High levels of hCG are associated with such signs of the early pregnancy like vomiting and nausea. [20]

2.4.2 Progesterone and Estrogen

Progesterone is necessary for pregnancy establishment and maintenance. It is produced by the corpus luteum in the early stages of pregnancy but its main production occurs in the placenta afterwards. The functions of progesterone include endometrium development and maintenance, aiding implantation process, decreasing uterine contractions, and assisting mammary tissue development in a pregnant woman. It also affects the gastrointestinal system and smooth muscles which can lead to symptoms like constipation, reflux, and slow intestinal motility in pregnant women. [21] The levels of estrogens including estradiol, estriol, and estrone rise significantly during pregnancy and the production occurs through the interaction of the fetal and mom's tissues. The function of estrogens involves stimulation of the uterus, improvement of the placental blood supply, and preparation of the mammary glands for milk production. The rise of the estrogen levels also leads to an increase in blood circulation and a number of other changes during pregnancy. [22]

2.4.3 Human Placental Lactogen (hPL)

Human placental lactogen (hPL), which is sometimes referred to as human chorionic somatomammotropin, is secreted by the placenta and generally becomes more abundant with the progression of the pregnancy and placental mass. hPL contributes to metabolism in the mother because it delivers nutrients needed for the development of the fetus. It works by decreasing insulin sensitivity and increasing the amount of glucose and fatty acids that enter the bloodstream, which is necessary to provide enough energy for the fetus. Besides metabolic processes, hPL is involved in breast development to prepare the mother's body for lactation. Its effect on metabolism is especially important at the later stages of pregnancy when the

demand for the fetus's nutrition is higher. The natural trend towards increased insulin resistance caused by placental hormones is normally compensated for by increasing the production of insulin by the mother. However, this compensation may be insufficient in some cases leading to gestational diabetes mellitus. [23]

2.4.4 Other Hormonal Changes

During pregnancy, the levels of different hormones change that help the mother adapt and the fetus mature. Relaxin is a hormone secreted by the corpus luteum and the placenta and helps relax pelvic ligaments as well as the cervix for the birth process. Prolactin slowly increases during pregnancy but due to high levels of estrogen and progesterone, no milk will be secreted before the child is born. In addition to these hormones, the thyroid hormones also are influenced by pregnancy. The increase level of thyroid-binding globulin and the stimulating activity of hCG influences the level of thyroid hormones in the body especially in the first trimester of pregnancy. The requirement of mothers for thyroid hormones grows with their need to take care both of mother's metabolism and fetus development. The levels of cortisol change in the blood during pregnancy which helps the bodies of mothers and children adapt. In this manner, changes occur in the endocrine system during pregnancy when hormones secreted by different organs, such as the placenta, ovaries, pituitary gland, thyroid gland, and adrenal cortex, effectively operate together to ensure pregnancy and promote the wellbeing of the fetus. Moreover, the changes in hormones contribute to the majority of physical and metabolic changes occurring in the body of the pregnant woman. [24]

2.5 Maternal Physiological Adaptations

As mentioned in (Table 2.3) all organ systems in a pregnant woman's body undergo physiological changes to promote fetal development, pregnancy maintenance, and prepare for delivery and breastfeeding. These adaptations become evident during the first trimester and evolve throughout the pregnancy. While the most changes are physiological and thus can be reverted after labor, some can manifest as pathological conditions.

2.5.1 Cardiovascular and Hematological Changes

The cardiovascular system has undergone a fundamental change due to pregnancy to adapt for the needs of both the mother as well as the fetus. The overall blood volume and cardiac output has increased considerably, while systemic vascular resistance has decreased owing to vasodilation. Consequently, blood pressure decreases during the first two trimesters and gradually comes to its pre-pregnancy levels. The enlarging uterus also may lead to impeded venous return, especially when lying down. The plasma volume is larger than the amount of red blood cells resulting in physiological anemia occurring in the course of pregnancy. The increase in the number of red blood cells lets the mother form more red cells and obtain proper intake of iron during pregnancy. [25]

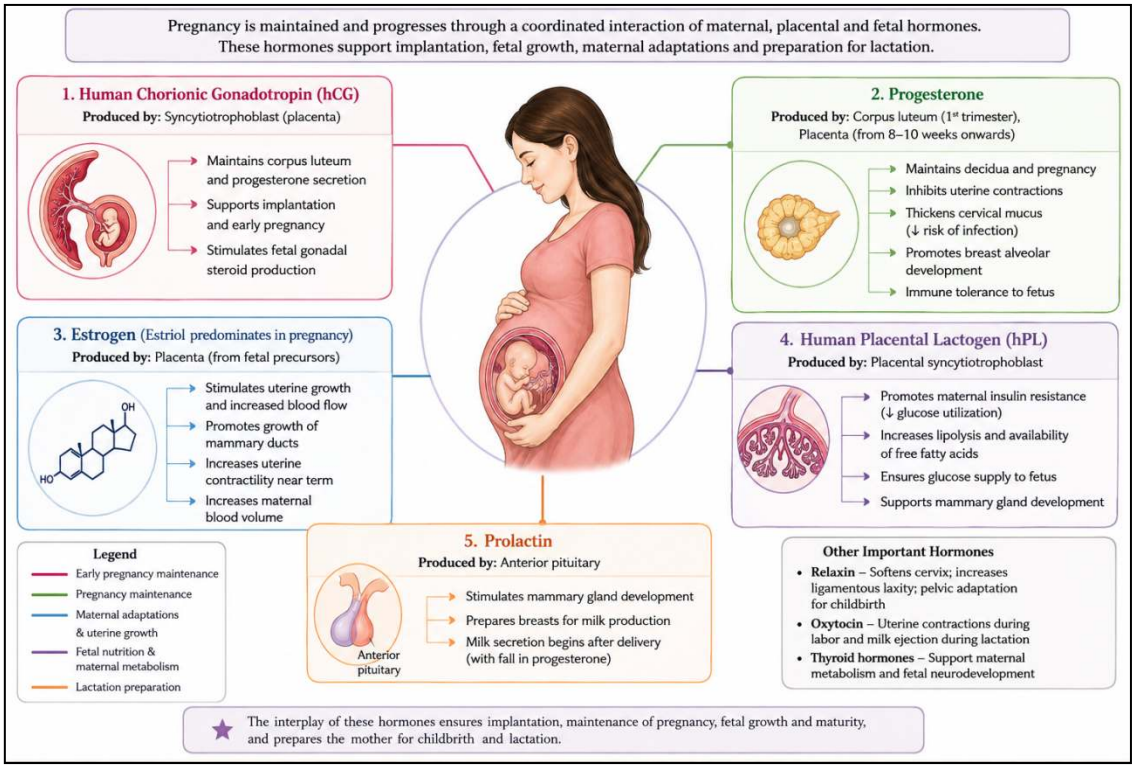


Figure 2.1: Major Hormonal Changes during Pregnancy

2.5.2 Respiratory and Renal Changes

During pregnancy, there are changes in respiration due to the increased demand of both the mother and fetus for oxygen. The levels of progesterone during pregnancy elevate ventilation by increasing tidal volume; in addition, the diaphragm is elevated due to the growth of the uterus. The overall oxygen consumption will also improve in addition to some mild impairment of breathing, despite the presence of normal oxygen levels. The amount of blood that reaches the kidneys as well as the filtration of blood during pregnancy increases making the kidneys function better. Thus, the present concentrations of creatinine and urea will be lower than in women who are not pregnant. Some mild glucose in the urine may be noted. [26]

2.5.3 Gastrointestinal and Metabolic Changes

Progesterone levels rise along with the mechanical influence by the growing uterus, leading to a decline in gastrointestinal motility. [27] This condition can trigger constipation, bloating, gastroesophageal reflux, and heartburn. In the early stages of pregnancy, nausea and vomiting are common due to hormonal alterations. As pregnancy advances, the displacement of organs in the abdomen can influence digestion and appetite. Metabolic changes occur during pregnancy to supply a proper amount of nutrients to the fetus. In particular, insulin resistance

increases during the second and third trimesters, allowing glucose to reach the fetus. In addition, maternal levels of lipids (triglycerides) increase during pregnancy. [28]

2.5.4 Musculoskeletal and Skin Changes

Musculoskeletal changes which occur during pregnancy are due to greater body weight, different posture, changed mechanical properties of ligaments, and increasing size of the uterus. Shift to the anterior side causes the center of gravity to move and the lumbar curve to intensify, which may provoke pain in the back and pelvis as well. Essential hormonal effects such as the function of relaxin lead to increased mobility of ligaments, thus preparing the pelvis for childbirth. Changes in the skin during pregnancy consist of increased pigmentation of the areola, linea nigra, pigmentation of the face (melasma) or emergence of stretch marks (striae gravidarum). Increased blood flow may lead to gematosis in the palms or spider vein phenomena. Most of the changes in the skin disappear after the childbirth, although some of the pigmentation and striae may remain. [29]

2.5.5 Breast and Reproductive Changes

Breast development, tenderness, and elevated blood supply occur under the influence of the hormones estrogen, progesterone, and prolactin. The nipples and the areola will be more pronounced and colored in addition to Montgomery glands enlargement.A woman may produce the colostrum as the breast is ready for further lactation. The uterus expands, thus accommodating the developing fetus, the placenta, and the amniotic fluid. The circulation of blood in the vagina and uterus becomes larger, starting the process of softening and increasing vascular. Physiological leukorrhea is the increase of vaginal discharge, which is clear and odorless. [30]

Table 2.3: Major Maternal Physiological Changes during Pregnancy

Body System	Major Physiological Changes
Cardiovascular	Increased blood volume and cardiac output; reduced vascular resistance
Hematological	Plasma volume expansion and physiological anemia
Respiratory	Increased ventilation and oxygen consumption
Renal	Increased renal blood flow and GFR
Gastrointestinal	Reduced motility; increased reflux and constipation
Metabolic	Increased insulin resistance and lipid metabolism
Musculoskeletal	Altered posture and increased ligamentous flexibility
Skin	Increased pigmentation and striae
Breast	Enlargement and preparation for lactation
Reproductive	Uterine enlargement and increased vaginal secretions

2.6 Embryonic and Fetal Development

As shown in (Fig 2.2) Embryonic and fetal development is a complex process that starts at the time of fertilization and continues throughout the pregnancy of the mother. During this period, the fertilized egg undergoes several stages of cellular division, implantation, differentiation, organogenesis, and growth and development. The significance of the early development stages is that the disruption of the organogenesis results in developing structural malformations. Throughout the pregnancy, the aspects of organogenesis are changing into the aspects of development and maturation of the organ systems. The umbilical cord and the placenta are developing alongside the embryo and the fetus and are crucial for the processes of nutrient supply, exchange of gases, removal of wastes, regulation of the endocrine system, and the informational exchange between the mother and the fetus.

2.6.1 Fertilization and Implantation

Fertilization is the term used to describe the process of a sperm reaching and merging with an ovum. This takes place in a specific location known as ampulla of a Fallopian tube. The zygote, being a product of fusion of male and female genetic material, carries total diploid numbers of chromosomes. The zygote proceeds through division, referred to as cleavage, while heading towards uterus. Different stages of development, such as morula and its following stage of blastocyst, are distinguished as it moves to the endometrium. The first step in implantation occurs around six or seven days after the process of fertilization, when a blastocyst adheres to and enters the endometrium. The cells of the trophoblast are divided into a cytotrophoblast and a syncytiotrophoblast, with the second type of cells helping in the process of implantation. The successful implantation permits the connection of the developing conceptus with maternal blood circulation and later continues the process of its development. [31]

2.6.2 Embryonic Development

The embryonic period spans roughly from three weeks to eight weeks after fertilization process and is characterized as crucial stage in human development. During this time, the embryo undergoes rapid growth alongside considerable cellular changes. Gastrulation causes the emergence of three germ layers namely ectoderm, mesoderm, and endoderm, which will later develop into all body's essential organs and tissues. During the neurulation process, neural tube is formed, neural tube which later evolves to the brain and spinal cord. Most of the organs are created during the embryonic stage. The research has shown that the cardiovascular system starts active development from the first few weeks of life. The embryo starts folding and developing. Because of quick organ formation processes at this stage, embryo is vulnerable to negative influence from outside environment and various medications. [32]

2.6.3 Fetal Development

The onset of fetal development occurs at around the 9th week following fertilization and it extends until delivery. In contrast to the embryonic stage, that is recognized by the formation of organs, fetal development is noted for intensive growth, tissue differentiation, and the maturity of the already formed organs. The first part of the fetal development is marked by changes in the body proportions, the formation of some facial features, and increased movement of the limbs. In the course of pregnancy, the musculoskeletal system, muscles, and the nervous system, as well as the respiratory, circulatory, digestive, and urinary systems, develop. The rate of fetal growth is increasing throughout the second trimester when fetal movements become coordinated and are detected by the mother, and in the third trimester when the fetus is gaining much weight. By that time many organs become mature enough to make it possible for the baby to adapt to the environment outside the mother's womb.

2.6.4 Placental and Umbilical Development

Both fetal and maternal tissues come together to form the placenta, which acts as the primary link between the mother and her developing fetus. The development of the placenta happens just after the implantation as trophoblastic cells shortly begin to interact with the maternal endometrium. At the same time chorionic villi will progressively develop and will be connected to the maternal blood system, which provides necessary exchange of oxygen, nutrients, carbon dioxide, and metabolism waste products. Moreover, the blood of the mother and blood of the fetus remain usually separated from each other, but some substances may easily pass via various methods. Apart from its function of exchange, the placenta also works as a vital endocrine body producing hormones including human chorionic gonadotropin, progesterone, estrogens, and human placental lactogen. The hormones produced by the placenta together account for maintaining pregnancy and help the mother to adapt to changing body.

The structure that links the unborn baby to the placenta is called the umbilical cord. The umbilical cord usually has either two arteries and one vein which are surrounded by the connective tissue called Wharton's jelly. The umbilical vein carries oxygenated blood that is rich in nutrients from the placenta to the unborn baby; on the other side, the umbilical arteries carry oxygen-depleted blood along with the metabolic wastes from the unborn baby to the placenta. The placenta and umbilical cord perform crucial functions during pregnancy.

2.6.5 Development of Major Organ Systems

Major organ systems start to develop largely during the embryonic stage and also continue in development during the fetal period through progressive growth and maturation. The nervous system originates in the neural tube and undergoes significant differentiation. In addition to that, the brain and connections between neurons continue to develop through pregnancy after being formed. The development of the cardiovascular system starts early in order to create an

adequate blood circulation system. Consequently, the cardiovascular system matures with the development of the heart and blood vessels. The respiratory system starts its development in the embryonic stage, while during pregnancy, the major transformations occur in the lungs, including surfactant production.

The digestive system starts with the formation of the embryonal part of the gut and goes through several series of differentiation until the esophagus, stomach, intestines, liver, and pancreas can be recognized. The urinary system develops by going through a stage of the formation of the kidneys. The fetal kidneys contribute to the creation of the amniotic fluid before they start functioning at the level of urine production in the earlier stages of pregnancy. The musculoskeletal system develops via the creation of cartilage, bones, and muscles.

The processes that characterize the development of the reproductive system arise from embryonic tissues and take place during the prenatal period. During this period, male and female external genitalia take shape and become recognizable as formation takes place. Immune system maturation takes place as time elapses. Maternal immunoglobulin G is being transferred from mother to fetus via the placenta, providing essential immunological protection in the last trimester. The two processes of the development of organ systems occur simultaneously, with each stage of morphological development followed by functional maturity until an infant is born.

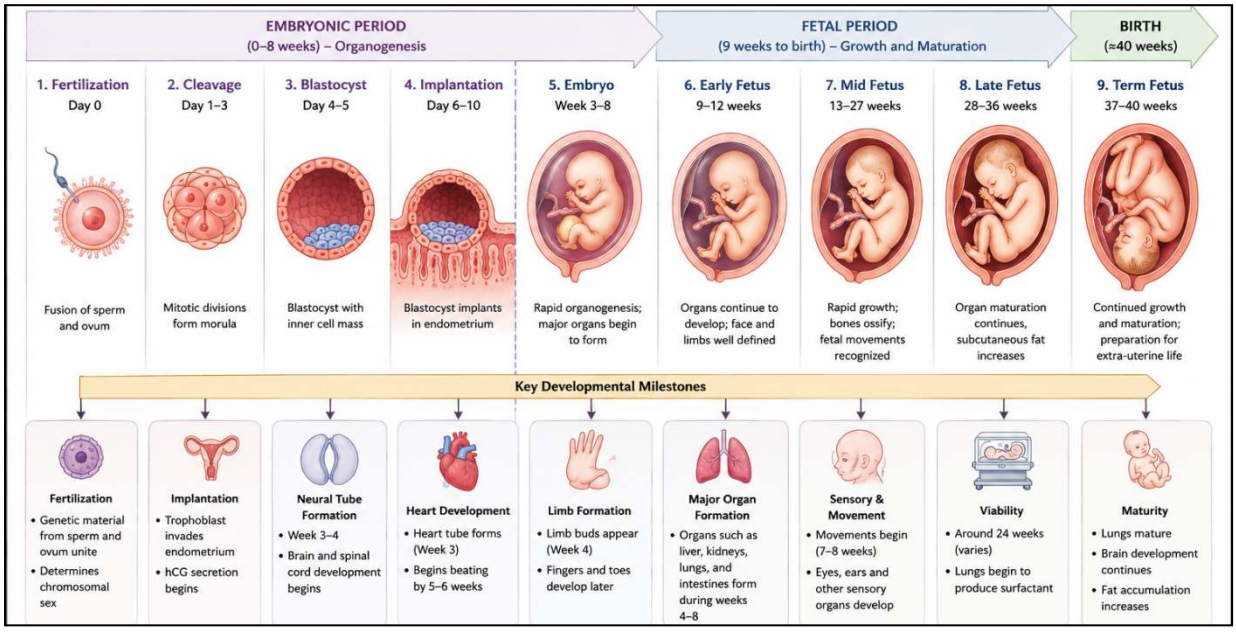


Figure 2.2: Embryonic and Fetal Development from Fertilization to Birth

2.7 Month-Wise Fetal Growth and Development

As shown in (Fig 2.3) the growth and development of the fetus take place continuously throughout pregnancy with each trimester having specific functional and anatomical features to deal with. The first trimester is primarily known for such events as implantation, development, and differentiation of organs, while the second trimester is noted for rapid body growth and movement. Finally, in the third trimester, fetal weight increases significantly and many organ systems including the brain and lungs are matured. [33]

2.7.1 First to Third Month

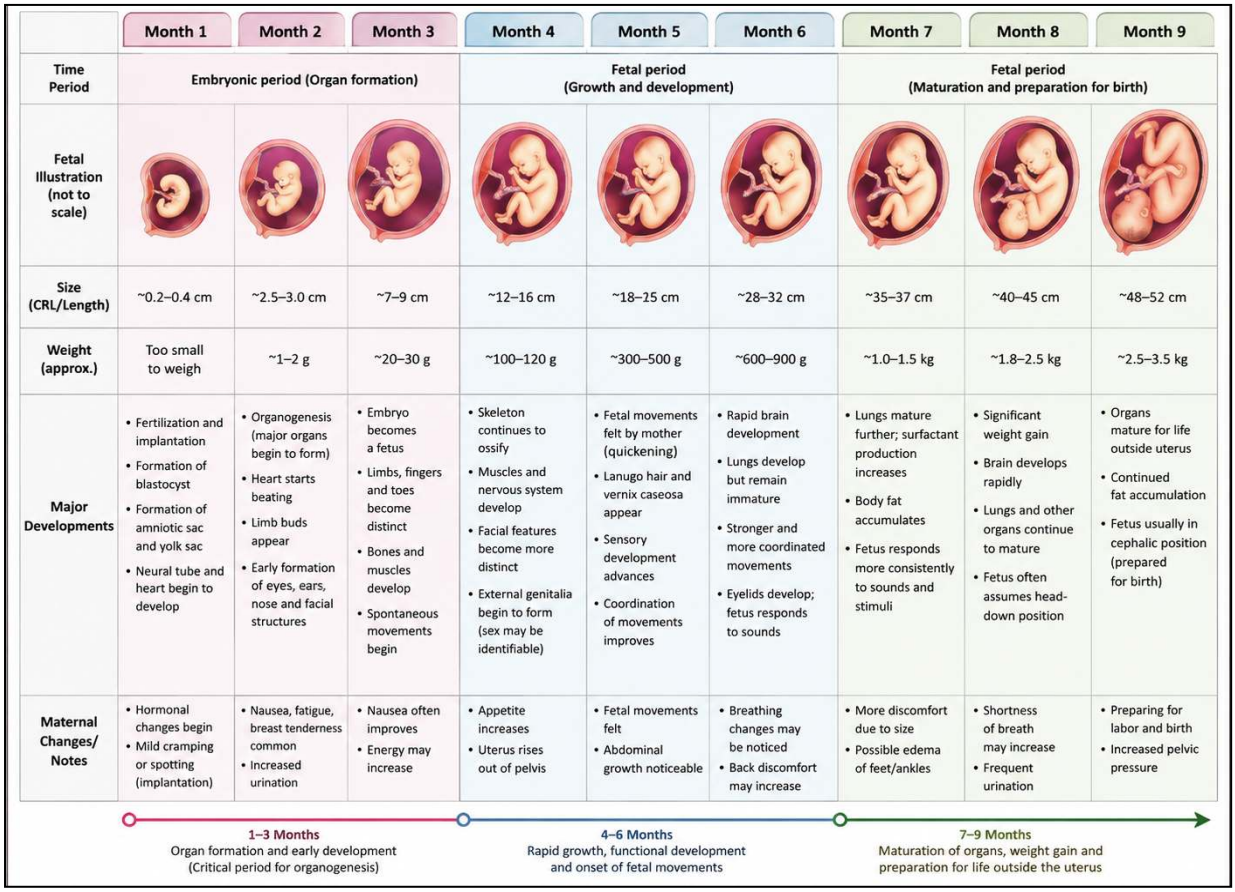
By the conclusion of the first month of pregnancy, the fertilized egg forms into a blastocyst, this attaches to the uterine lining. The embryonic disc, amniotic sac, yolk sac, neural tube, and other parts that are important in heart development also form at the same time. The second month is critical in embryo growth and the manifestation of its organs (brain, spinal cord, heart, fingers, eyes, ears). In the third month, the embryo starts to develop facial features, hands, and toes. Additionally, by the end of the first term of pregnancy, primary organs are already formed.

2.7.2 Fourth to Sixth Month

The development of the skeletal system, muscles, nervous system and facial organs persists in the fourth month, yet fetal movements are becoming more coordinated. By the fifth month, fetal movements become more vigorous and are detectable by the mother. The lanugo and vernix caseosa appear while sensory functions and nervous system development continue to mature. In the sixth month, the baby grows in weight, becoming more proportional. The brain keeps developing rapidly, and body movements become stronger while lungs are still immature. The skin is thin due to the lack of fat under the skin.

2.7.3 Seventh to Ninth Month

In the seventh month of pregnancy, significant growth and development of the brain, lungs, and other organs happen and the fetus starts to accumulate fat. In the eighth month, there is an enormous increase in weight along with the development of the nervous system and lungs. The baby may turn over and adopt a position for delivery. At the ninth month, the fetus continues to gain fat and develops various organs such as lungs and brain to prepare for its life outside the womb. Normally, a child assumes the position of head down but his position may vary.



	Month 1	Month 2	Month 3	Month 4	Month 5	Month 6	Month 7	Month 8	Month 9
Time Period	Embryonic period (Organ formation)			Fetal period (Growth and development)			Fetal period (Maturation and preparation for birth)		
Fetal Illustration (not to scale)									
Size (CRL/Length)	~0.2–0.4 cm	~2.5–3.0 cm	~7–9 cm	~12–16 cm	~18–25 cm	~28–32 cm	~35–37 cm	~40–45 cm	~48–52 cm
Weight (approx.)	Too small to weigh	~1–2 g	~20–30 g	~100–120 g	~300–500 g	~600–900 g	~1.0–1.5 kg	~1.8–2.5 kg	~2.5–3.5 kg
Major Developments	• Fertilization and implantation • Formation of blastocyst • Formation of amniotic sac and yolk sac • Neural tube and heart begin to develop	• Organogenesis (major organs begin to form) • Heart starts beating • Limb buds appear • Early formation of eyes, ears, nose and facial structures	• Embryo becomes a fetus • Limbs, fingers and toes become distinct • Bones and muscles develop • Spontaneous movements begin	• Skeleton continues to ossify • Muscles and nervous system develop • Facial features become more distinct • External genitalia begin to form (sex may be identifiable)	• Fetal movements felt by mother (quickening) • Lanugo hair and vernix caseosa appear • Sensory development advances • Coordination of movements improves	• Rapid brain development • Lungs develop but remain immature • Stronger and more coordinated movements • Eyelids develop; fetus responds to sounds	• Lungs mature further; surfactant production increases • Body fat accumulates • Fetus responds more consistently to sounds and stimuli	• Significant weight gain • Brain develops rapidly • Lungs and other organs continue to mature • Fetus often assumes head-down position	• Organs mature for life outside uterus • Continued fat accumulation • Fetus usually in cephalic position (prepared for birth)
Maternal Changes/ Notes	• Hormonal changes begin • Mild cramping or spotting (implantation)	• Nausea, fatigue, breast tenderness common • Increased urination	• Nausea often improves • Energy may increase	• Appetite increases • Uterus rises out of pelvis	• Fetal movements felt • Abdominal growth noticeable	• Breathing changes may be noticed • Back discomfort may increase	• More discomfort due to size • Possible edema of feet/ankles	• Shortness of breath may increase • Frequent urination	• Preparing for labor and birth • Increased pelvic pressure

Figure 2.3: Month-Wise Fetal Growth and Development

2.7.4 Key Developmental Milestones

Key growth stages of the fetus are implantation and organ formation in the first stage of pregnancy, fetal growth and movement in the second stage of pregnancy, and rapid development in the last trimester. Towards the end of the pregnancy, the fetus undergoes brain development, lung growth, accumulation of fat, and increase in the capability of different organ systems to perform their functions. Developmental timing may differ from one pregnancy to another; therefore, clinicians should assess fetal growth and health conditions according to the gestational age of the pregnancy and data gained through clinical and ultrasonographic approaches.

2.8 Common Pregnancy Symptoms and Management

The gestation period results in many hormonal, physiological, and anatomical changes that can be manifested through various symptoms. Some of the symptoms occur more frequently during the first trimester while others become noticeable later in the pregnancy process. Most common symptoms are physiological in nature and can be treated through reassurance, nutrition, proper

sleeping patterns, hydration, physical activities, and other supportive methods. Nevertheless, some symptoms require evaluation since they can be troublesome and indicate possible complications.

2.8.1 Nausea and Vomiting

Nausea and vomiting commonly experienced in early pregnancy, known as morning sickness, can occur at any time and usually occur approximately at the beginning of pregnancy, and the symptoms tend to improve at the beginning of the second trimester. They are thought to be triggered by changes in hormone levels such as increased hormone beta-HCG and estrogen. Certain foods, strong sights and smells, fatigue and long periods without food can all worsen symptoms. The treatment is mainly supportive - small and frequent meals, appropriate amounts of liquids, avoiding offending foods and eating foods that are easy to digest can help relieve symptoms. Ginger and vitamin B6 may be useful in some people. If symptoms are so severe that interfere with normal life, an antiemetic may be prescribed. [34]

2.8.2 Fatigue and Breast Tenderness

During the first trimester of pregnancy, women tend to suffer from fatigue easily since they are faced with hormonal shifts, increased metabolism, behavioral changes, and changes in sleep pattern, which all contribute to the presence of fatigue. The condition may improve in the second trimester but may come back in the third trimester because of increased physical demands made of women as well as because of sleep disturbances. However, the condition can be controlled through proper sleep, planned resting time, balanced nutrition, hydration, and regular light or moderate exercise. Breast tenderness, swelling, and sensitivity often take place during pregnancy due to the increasing level of the female hormones. With a rise in the blood circulation and the growth of the mammary glands, women`s breasts prepare to serve as lactating organs. Wearing a proper supportive bra, comfortable clothes as well as avoiding any pressure on the breasts can help overcome and lessen the problem of discomfort.

2.8.3 Heartburn and Constipation

Heartburn and acid reflux are common problems faced during pregnancy. Higher progesterone levels relax the lower esophagus and cause decreased bowel movements while the uterus can put pressure on the stomach later in the pregnancy. Eating smaller portions, avoiding certain foodstuffs, keeping the body in an upright position after meals, and steering clear of eating before going to bed will help mitigate the problem. If there is no success with modifications of lifestyle, the next step is taking antacids or other medication suitable during pregnancy, provided that it is done under the supervision of a medical specialist. Constipation is a common condition also, which occurs due to the drop in intestinal motility because of the hormones as well as the pressure that the growing uterus puts on the intestine. Iron supplements taken during pregnancy can additionally cause constipation. However, increasing the amount of fiber in the

diet by eating fruits, vegetables, whole grain products, and other high-fiber foods comes to help.

2.8.4 Urinary and Musculoskeletal Symptoms

Frequent urination is a typical symptom experienced during pregnancy. The condition occurs in the early stages of pregnancy due to hormonal changes and the effects of improved circulation, but in later pregnancy, urination may also be caused by the pressure from the growing uterus. Adequate fluid intake should be ensured without intentionally limiting the fluid intake. Symptoms of a urinary infection such as burning sensation when urinating, fever, the presence of blood in urine, and pain in the lower abdomen or back may necessitate medical attention. Increased weight gain during pregnancy can cause pain in the back, pelvis, and legs. Some of the other contributing factors to the discomfort can be a change in posture, a shift in the center of gravity, and the relaxation of joints due to the changes in hormone concentrations. Good posture, physical activity suitable for pregnant women, gentle stretching, comfortable footwear, and avoid standing for long hours can alleviate the pain.

2.8.5 Edema and Other Common Symptoms

There are frequent instances of mild swelling in foot and ankle areas during pregnancy. The reason behind this could be attributed to fluid buildup and pressure acting on pelvic veins due to the increasing size of the uterus. Some of the effective some methods of dealing with the symptoms of swelling include walking, avoiding standing for too long, resting with feet elevated, consuming an adequate amount of fluid and using good quality footwear. Nevertheless, in case of sudden swelling or swelling of a significant degree especially on face and hands, this may indicate a condition called gestational hypertension which will call for immediate medical intervention. The common symptoms of pregnancy may include headache, dizziness, nasal stuffiness, cramps in the legs, mild pain in the pelvis, and increased discharge from the vagina, resulting from hormonal, circulatory, and mechanical changes. Resting, drinking enough water, eating balanced meals, and avoiding individual stimuli can help alleviate some mild symptoms.

2.8.6 Warning Signs Requiring Medical Attention

While a number of the common indicators during pregnancy are seen as normal, some symptoms can be a signal of a serious condition with either the expecting mother or her unborn baby. Within the scope of the above mentioned symptoms, those like heavy vein bleeding, severe constant pain in the tummy or the pelvic region, a headache, sudden swelling of either the hand or face, symptoms of having heart issues, fainting, developing seizures, persisting fever persistently, and very low fetal activity later in time should be treated with a great priority and improved diagnosis. A pregnant woman should be informed of these signs and encouraged to seek medical help instead of treating herself. The investigations may include physical

examination, checking blood pressure, doing some laboratory tests and conducting ultrasonography. [35]

2.9 References

1. McNestry C, Killeen SL, Crowley RK, McAuliffe FM. Pregnancy complications and later life women's health. Acta Obstetricia et Gynecologica Scandinavica. 2023 May;102(5):523-31.
2. Valsamakis G, Chrousos G, Mastorakos G. Stress, female reproduction and pregnancy. Psychoneuroendocrinology. 2019 Feb 1;100:48-57.
3. Jarvis S, Nelson-Piercy C. Common symptoms and signs during pregnancy. Obstetrics, Gynaecology & Reproductive Medicine. 2020 Oct 1;30(10):321-5.
4. Jordan RG, Cockerham AZ. Common discomforts of pregnancy. Prenatal and Postnatal Care: A Person-Centered Approach. 2023 Sep 6;233.
5. Robinson JH. What the pregnancy test is testing. The British Journal of Sociology. 2020 Jun;71(3):460-73.
6. Detti L, Francillon L, Christiansen ME, Peregrin-Alvarez I, Goedecke PJ, Bursac Z, Roman RA. Early pregnancy ultrasound measurements and prediction of first trimester pregnancy loss: A logistic model. Scientific reports. 2020 Jan 31;10(1):1545.
7. Shulman HB, D'Angelo DV, Harrison L, Smith RA, Warner L. The pregnancy risk assessment monitoring system (PRAMS): overview of design and methodology. American journal of public health. 2018 Oct;108(10):1305-13.
8. Tsakiridis I, Giouleka S, Mamopoulos A, Athanasiadis A, Dagklis T. Investigation and management of stillbirth: a descriptive review of major guidelines. Journal of Perinatal Medicine. 2022 Jul 26;50(6):796-813.
9. Talebi S, Mehdizadeh A. Nutritional requirements in pregnancy and lactation. Clinical nutrition ESPEN. 2024 Dec 1;64:400-10.
10. Adams JB, Kirby JK, Sorensen JC, Pollard EL, Audhya T. Evidence based recommendations for an optimal prenatal supplement for women in the US: vitamins and related nutrients. Maternal health, neonatology and perinatology. 2022 Jul 11;8(1):4.
11. Barrow A, Barrow S, Jobe A. Differentials in prevalence and correlates on uptake of tetanus toxoid and intermittent preventive treatment with sulfadoxine-pyrimethamine during pregnancy: A community-based cross-sectional study in The Gambia. SAGE Open Medicine. 2022 Jan;10:20503121211065908.
12. Volpe N, Sen C, Turan S, Sepulveda W, Khalil A, Rolnik DL, De Robertis V, Volpe P, Gil MM, Chaveeva P, Dagklis T. First trimester examination of fetal anatomy: clinical practice guideline by the World Association of Perinatal Medicine (WAPM) and the

Perinatal Medicine Foundation (PMF). Journal of Perinatal Medicine. 2022 Sep 27;50(7):863-77.
13. Pruthi V, Abbasi N, Thakur V, Shinar S, O'Connor A, Silver R, Simpson T, Van Mieghem T. Performance of comprehensive first trimester fetal anatomy assessment. Prenatal Diagnosis. 2023 Jun;43(7):881-8.
14. Chaemsaithong P, Sahota DS, Poon LC. First trimester preeclampsia screening and prediction. American journal of obstetrics and gynecology. 2022 Feb 1;226(2):S1071-97.
15. Agten AK, Jurkovic D, Timor-Tritsch I, Jones N, Johnson S, Monteagudo A, Huirne J, Fleisher J, Maymon R, Herrera T, Prefumo F. First-trimester cesarean scar pregnancy: a comparative analysis of treatment options from the international registry. American journal of obstetrics and gynecology. 2024 Jun 1;230(6):669-e1.
16. Nelson-Piercy C, Dean C, Shehmar M, Gadsby R, O'Hara M, Hodson K, Nana M, Royal College of Obstetricians and Gynaecologists. The Management of Nausea and Vomiting in pregnancy and hyperemesis gravidarum (green-top guideline No. 69). BJOG: An International Journal of Obstetrics & Gynaecology. 2024 Jun;131(7):e1-30.
17. Wang MY, Smolinski PN, Thai BT, Sarayani MA, Ewig PC, Winterstein FA. Common teratogenic medication exposures—a population-based study of pregnancies in the United States. American journal of obstetrics & gynecology MFM. 2024 Jan 1;6(1):101245.
18. McAllister A, Lang B, Flynn A, Meisel ZF, Abernathy A, Sammel MD, Schreiber CA. Pregnant and bleeding: A model to assess factors associated with the need for emergency care in early pregnancy. The American journal of emergency medicine. 2022 Mar 1;53:94-8.
19. Gesese SS, Mersha EA, Balcha WF. Knowledge of danger signs of pregnancy and health-seeking action among pregnant women: a health facility-based cross-sectional study. Annals of Medicine and Surgery. 2023 Apr 11;85(5):1722.
20. Larraín D, Caradeux J. β-Human Chorionic Gonadotropin Dynamics in Early Gestational Events: A Practical and Updated Reappraisal. Obstetrics and Gynecology International. 2024;2024(1):8351132.
21. Parisi F, Fenizia C, Introini A, Zavatta A, Scaccabarozzi C, Biasin M, Savasi V. The pathophysiological role of estrogens in the initial stages of pregnancy: molecular mechanisms and clinical implications for pregnancy outcome from the periconceptional period to end of the first trimester. Human reproduction update. 2023 Nov 1;29(6):699-720.
22. Jin C, Peng Y, Luo X, Zhu Q, Lin L, Yang J, Wang P. Dynamic change of estrogen and progesterone metabolites in human urine during pregnancy. Scientific Reports. 2025 Mar 11;15(1):8409.

23. Jankovic-Karasoulos T, Smith MD, Leemaqz S, Williamson J, McCullough D, Arthurs AL, Jones LA, Bogias KJ, Mol BW, Dalton J, Dekker GA. Elevated maternal folate status and changes in maternal prolactin, placental lactogen and placental growth hormone following folic acid food fortification: Evidence from two prospective pregnancy cohorts. Nutrients. 2023 Mar 23;15(7):1553.
24. Ammari R, Monaca F, Cao M, Nassar E, Wai P, Del Grosso NA, Lee M, Borak N, Schneider-Luftman D, Kohl J. Hormone-mediated neural remodeling orchestrates parenting onset during pregnancy. Science. 2023 Oct 6;382(6666):76-81.
25. Samara A, Khalil A. Cardiovascular Changes in Pregnancy: Reference Ranges and Role of Maternal Characteristics. InMaternal Hemodynamics 2026 Jan 21 (pp. 21-41). Cham: Springer Nature Switzerland.
26. Ejikeme C, Nandakumar V, Gotur D. Respiratory physiological changes in pregnancy. Respiratory medicine. 2025 Sep 1;246:108245.
27. Gorczyca K, Obuchowska A, Kimber-Trojnar Ż, Wierzchowska-Opoka M, Leszczyńska-Gorzelak B. Changes in the gut microbiome and pathologies in pregnancy. International Journal of Environmental Research and Public Health. 2022 Aug 12;19(16):9961.
28. Koren O, Konnikova L, Brodin P, Mysorekar IU, Collado MC. The maternal gut microbiome in pregnancy: implications for the developing immune system. Nature reviews Gastroenterology & hepatology. 2024 Jan;21(1):35-45.
29. Leung CJ, Tao F, Senter C, Ramirez FD, Wong SE. Pregnancy-related hip and pelvis musculoskeletal conditions, risk factors, and prevention. Current Reviews in Musculoskeletal Medicine. 2025 Dec;18(12):585-98.
30. Margioula-Siarkou G, Margioula-Siarkou C, Petousis S, Vavoulidis E, Margaritis K, Almperis A, Haitoglou C, Mavromatidis G, Dinas K. Breast carcinogenesis during pregnancy: molecular mechanisms, maternal and fetal adverse outcomes. Biology. 2023 Mar 6;12(3):408.
31. Awonuga AO, Camp OG, Abu-Soud HM, Rappolee DA, Puscheck EE, Diamond MP. Determinants of embryo implantation: roles of the endometrium and embryo in implantation success. Reproductive Sciences. 2023 Aug;30(8):2339-48.
32. Rossant J, Tam PP. Early human embryonic development: Blastocyst formation to gastrulation. Developmental cell. 2022 Jan 24;57(2):152-65.
33. Ling AL. Role of Garbhini paricharya in reducing gestational complications and improving perinatal outcomes: A prospective cohort study. Journal of Kaumarbhritya and Stree Vigyan. 2025;2(2):71-8.
34. Bottone-Post C. Nausea and vomiting of pregnancy. InClinical Pharmacology During Pregnancy 2022 Jan 1 (pp. 155-176). Academic Press.

35. Shedden-Mora M, Schymanski V, Albers R, Beth B, Garthus-Niegel S, Crum AJ, Autzen L. Expectations predict early pregnancy-related symptom burden. Scientific Reports. 2026 Jun 16;16(1):18705.