

Physiology and Maternal Adaptation of Pregnancy

Diagnosis of pregnancy

First trimester (first 12 weeks)

Symptoms

1. Amenorrhoea
2. Morning sickness – more often in the first pregnancy than in the subsequent one. It usually appears soon following the missed period and rarely lasts beyond the 3rd month
3. Breast discomfort
4. Frequency of micturition
5. Constipation
6. Enlargement of abdomen
7. Fatigue
8. Fetal movement

Signs

- **Breast:** Engorgement of breast with dilatation of superficial veins
 - Areola more pigmented
 - Montgomery's tubercles are prominent
 - Secretion as early as 8th week
- **Per abdomen** – uterus remains a pelvic organ until at 12th week
- Pelvic changes
 - **Chadwick's sign** – It is the dusky blue of anterior vaginal wall visible at about 8th week of pregnancy. The discolouration is due to local vascul
 - **Uterine signs** – the pregnant uterus feels soft and elastic
 - **Hegar's sign** – 6-10 weeks

Immunological test

- Depends on agglutination reaction of the antigen (HCG)

Sonography

- Gestational ring
- Cardiac motion uniformly by 7th week

Second trimester (13-28 weeks)

- Quickening
- Progressive enlargement of the lower abdomen
- General examination
 - **Chloasma**
 - **Breast changes:** more enlarged with prominent veins under the skin. Secondary areola specially demarcated in primigravidae, Montgomery's tubercles are prominent. Colostrum becomes thick and yellowish by 16th week. Variable degree of striae may be visible with advancing weeks.

Abdominal examination

- Inspection
 - Fundal height
- Palpation
 - The uterus feels soft and elastic
 - Braxton-Hicks contractions
 - Palpation of foetal parts
 - Active foetal movements
- Auscultation

Last trimester (29-40 weeks)

- Enlargement of the abdomen
- Foetal movement
- Braxton-Hicks
- Foetal movements

Differential diagnosis of pregnancy

- Cystic ovarian tumour, fibroid, distended urinary bladder

Physiological changes during pregnancy

- **Vulva**
 - Superficial varicosities may appear
 - Labia minora are pigmented and hypertrophied
- **Vagina**
 - Increased blood supply of the venous plexus surrounding the walls give the bluish colouration of the mucosa (Jacquemier's sign)
- **Secretion**
 - The secretion becomes copious
 - pH becomes acidic (3.5-6)
- **Uterus**
 - The uterus which is non-pregnant state weighs about 50mg and measures about 7.5 cm in length, at term weighs 900-1000 gm and measures 35 cm in length
- **Enlargement**
 - Hypertrophy and hyperplasia
 - Stretching
- **Lateral obliquity**
- **Contractions (Braxton-Hicks)**
 - The contractions are irregular, infrequent, spasmodic and painless without any effect on dilatation of the cervix
- **Breast**
 - Changes in the breasts are best evident in a primigravida
 - Marked hypertrophy and proliferation of the ducts
 - Hypertrophy of the connective tissue stroma
- **Nipples and areola**
 - Nipples become deeply pigmented
 - Sebaceous glands remain visible (Montgomery's tubercles)

- **Cutaneous changes**

- Face

- Chloasma gravidarum or pregnancy mask, extreme form of pigmentation around the cheek, forehead and around the eyes. It may be patchy or diffuse, disappears spontaneously after delivery

- Abdomen

- Linea nigra – brownish black pigmented area in the midline stretching from the xiphisternum to the symphysis pubis
- Striae gravidarum – represent the tissue in the deeper layer of the cutis, mechanical stretching

- Weight gain

- The total weight gain during the course of a singleton pregnancy average 11kg). This has been distributed to 1kg in first trimester and 5kg each in second and third trimester

Cardiovascular changes

- Position and size of heart

- ECG changes

- Increased heart rate (+15%)
- 15-degree left axis deviation
- Inverted T-waves in lead III
- Q in lead III and AVF
- Unspecific ST changes

- Appear larger on roentgenogram

- **Heart rhythms and murmurs:** soft , transient

- **Caution:** How to interpret these murmurs

- **Inferior vena cava syndrome:**

- In the supine position, the inferior vena cava is compressed by the enlarged uterus, resulting in decreased cardiac output. Some women may have symptoms that include dizziness, light-headedness, and syncope.

- Stroke volume +30%

- Heart rate +15%

- Cardiac output +40%

- Oxygen consumption +20%

- SVR (systemic vascular resistance) -5%

- Systolic BP -10mmHg

- Diastolic BP -15mmHg

- Mean BP -15mmHg

- Blood volume +30%

- Plasma volume +40%

- Red blood cell volume +20%

- Dilutional anemia

- Increase cardiac output
- Decrease blood viscosity
- Vasodilatation
- Right shift oxyhemoglobin dissociation curve

- **Venous pressure:**

1. Unchanged in the upper body
2. Significantly increases in the lower extremities, esp. during supine, sitting or standing position, returns to near normal in lateral recumbent position

Hematologic system

- Blood volume (polymorphonuclear) +40%
- Dilutional anemia Hb 110 g/L
- Leukocytosis 15,000/ml
- Platelet not change
- Sedimentation rate increase, 100m/h

- **Clotting factors: hypercoagulable, throboembolism**
 - Fibrinogen (factor I) +50% (4.5 vs 3 g/L)
 - Factor VIII increase
 - Factors VII, IX, X and XII increase
 - Prothrombin time, PT shortened
 - ATPP activated partial thromoplastin time shortened
 - Fibrinolytic activity decrease

- **Iron : active transplacental transfer**
 - Requirement 1000mg
 - increase maternal red cell mass 500mg
 - fetal development 300mg
 - compensate for normal iron loss 200mg
- To supply, 300 mg of ferrous sulfate is needed, and twice the dose for anemic patients.

Physiological changes during pregnancy (contd...)

- Leucocytes
 - Neutrophilic leucocytosis occurs to the extent of 10-15,000/cu.mm and even to 20,000/cu.mm in labour
The increase is due to rise in the number of mature and immature neutrophils
- Total protein
- Supine hypotension syndrome (postural hypotension)
- Carbohydrate metabolism
- Glycosuria – lowered renal threshold, increased glomerular filtration, due to rapid absorption of carbohydrate from the gut

• Systemic Changes

	Change
Respiration rate/min	Unaffected
Vital capacity (ml)	Almost unaffected
Tidal volume (ml)	+40%
Residual volume (ml)	-20%

- **Nervous system**
 - May be generalised neuritis probably due to vitamin B1
 - Compression of the lumbosacral trunk by the foetal head or by features of sciatica
 - Compression of the median nerve (Carpal tunnel syndrome)
- **Calcium metabolism**
 - Daily requirement of calcium during pregnancy average 1-1.5

Hemodynamic changes during pregnancy

- Decreased peripheral vascular resistance
- Decreased pulmonary vascular resistance
- Decreased colloid oncotic pressure
- Increased cardiac output
- Increased pulse rate

	Non-pregnant	Pregnant
Cardiac output (L/min)	4.3 ± 0.9	6.2 ± 1.0
Heart rate (bpm)	71 ± 10.0	83 ± 10.0
Systemic vascular resistance (dyne –cm –sec-5)	1530 ± 520	1210 ± 266
Pulmonary vascular resistance (dyne –cm –sec-5)	119 ± 47.0	78 ± 22

Changes in the kidneys and the urinary system

Anatomical changes

- Dilatation of the collecting system
 - The renal calices, the renal pelvis and the ureters starts to dilate and remain enlarged for several weeks after delivery
 - Causes
 - Progesterone
 - Compression of the ureter

Physiological changes

- Increase in renal plasma flow (RPF)
- Increase in glomerular filtration rate (GFR)
- The most important consequence of the increased RPF is a 50% increase in the GFR
- The serum creatinine and urea nitrogen concentration below lower than in the non-pregnant situation

Endocrinology in relation to reproduction

Hormones of placenta

- Protein hormones
 - Human chorionic gonadotrophin (HCG)
 - Human placenta lactogen (HPL)
 - Human chorionic thyrotrophin (HCT)
 - Human chorionic corticotrophin (HCC)
 - Pregnancy specific b-1 glycoprotein (PS b G)
- Steroid hormones
 - Oestrogens – oestriol, oestradiol and oestrone
 - Progesterone
- Besides these hormones, placenta also produces releasing hormones, enzymes and protein. These are:
 - i) TSH releasing hormone (TRH)
 - ii) LH/FSH releasing hormones (LH/FSH-RH).

Placental hormones

- Essential for foetal growth and development
- Influences maternal physiology

Estrogen and progesteron

- 100 fold increase in progesteron concentration
- Estrogen levels are also very high
- The level of SHBG increases

Adrenal cortical hormones

- Increased level of plasma cortisol
- There is hyperplasia of zona fasciculata and increase in adrenal androgens – helps in protein anabolism
- Increase in aldosteron secretion

Thyroid gland

- Moderate enlargement with hyperplasia
- Increased secretion of thyroid hormones

Parathyroid gland

- Enlarged with increase secretion of parathyroid hormone to facilitate mobilization of ionic calcium and phosphorus for fetal bone development
- Calcitonin level slightly increased just to counter the effect of PTH on maternal skeleton

Pancreas

- Hypertrophy and hyperplasia of beta cell of Langerhans
- Pregnancy has diabetogenic effect
- In pregnancy – hyperglycemia, hyperinsulinemia, hypertriglyceridemia and reduced sensitivity to insulin
- Increased resistance to insulin is because of HPL, E, P

Diabetogenic effects of pregnancy

- Insulin resistance
 - Production of placental somatomammotropin
 - Increased production of cortisol, estriol, and progesterone
 - Increased insulin destruction by kidney and placenta
- Effect of pregnancy on diabetes
 - More insulin is necessary to achieve metabolic control
 - Progression of diabetic retinopathy
 - Worsening of diabetic nephropathy
 - Increased risk of death for patients with diabetic cardiomyopathy

Human chorionic gonadotrophin (HCG)

- Functions
 - Secretion of progesterone by the corpus luteum of pregnancy
 - HCG stimulates Leydig cells of the male foetus to produce testosterone in conjunction with foetal pituitary gonadotrophins. It is thus indirectly involved in the development of male external genitalia
 - It has got immuno-suppressive activity which may inhibit the maternal processes of immunorejection of the foetus as a homograft

Human placental lactogen (HPL)

Pregnancy specific b-1 glycoprotein (PS bG)

- Can be used as a specific test for pregnancy

Other protein hormones

- HCT, HCCT, TRH and FSH/LH releasing hormones
- Functions : Perhaps involved in accelerating the activity of the thyroid, adrenal cortex

Steroidal hormones

- Oestrogen
- Progesteron
 - Functions
 - Together maintenance of pregnancy. Oestrogen causes hypertrophy and hyperplasia of the uterine myometrium, thereby increasing the accommodation capacity, vascularity and blood flow of the uterus.
 - Progesterone in conjunction with oestrogen stimulates growth of the uterus
 - Development and hypertrophy of the breasts. Hypertrophy and proliferation of the ductus are due to oestrogen
 - Both the steroids are required for the adaptation of the maternal organ to the constantly increasing demands of the growing foetus
 - The steroids are involved in the complex pathway in initiation of normal labour

Metabolic changes

Are necessary to meet the demand of growth fetus and for maternal adjustment

Carbohydrate metabolism

- Foetus drives its energy almost totally from glucose, passed through placenta by facilitated diffusion

Lipid metabolism

- Increased mobilization of lipids from maternal adipose tissue to raise plasma FFA level
- HPL has glucose sparing effect by mobilizing free fatty acid for mothers skeletal and cardiac muscles and diverting the glucose to placenta and fetus

Salt and water metabolism

- Marked water retention is found in pregnancy with the decrease in plasma osmolarity
- Odema of legs seen because of increased venous pressure due to compression by gravid uterus
- Increase in blood volume causes decreased oncotic pressure causes leakage of water in the tissue bed.
- The reduction in serum, sodium is caused by increased GFR. However, sodium and fluid balance is maintained by increase in plasma aldosteron and increase level of estrogen and deoxycorticosterone prevents sodium loss
- Weight gain

Placental Function

The main functions of the placenta are

- Transfer of nutrients and waste products between the mother and foetus. In this respect it attributes to the following functions
 - Respiratory
 - Excretory
 - Nutritive
- Produces or metabolises the hormones and enzymes necessary to maintain the pregnancy
- Barrier function
- Immunological function

Enzymatic function

- Diamine oxidase – inactivate circulatory pressure amines
- Oxytocinase – neutralises the oxytocin
- Phospholipase A2

Amniotic fluid

Origin

- As a transudate from the maternal serum across the foetal membranes
- As a transudate across the umbilical cord
- Contribution from the foetal urine
- Secretion from the tracheobronchial tree

Functions – main functions is protective to the foetus

- Shock absorber
- Maintains an even temperature
- Allows the space for growth and free movement of the foetus

During labour

- Dilatation of the cervix
- Flushes the birth canal