



[Color index: **Important** | **Notes** | Extra]



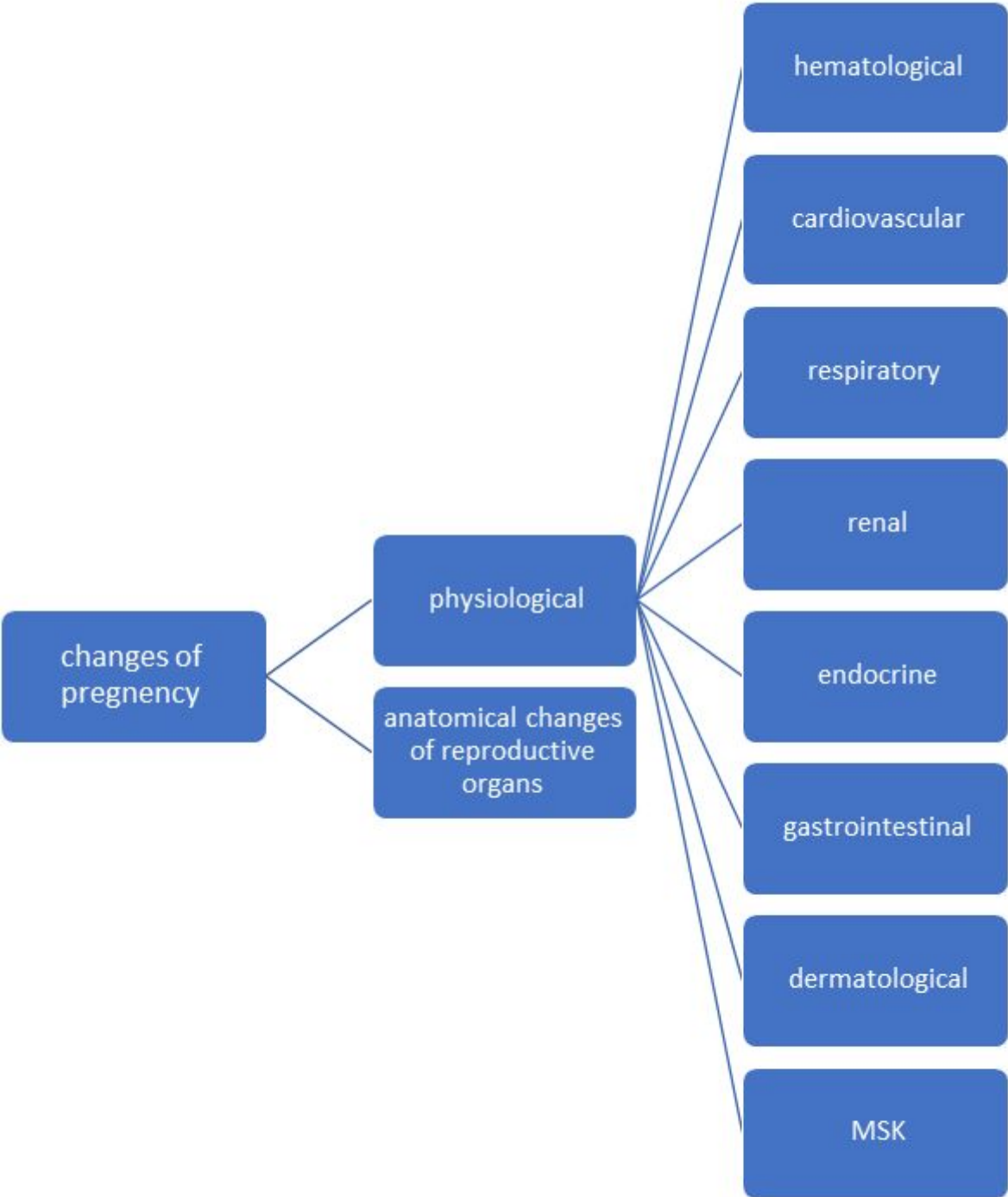
PHYSIOLOGICAL CHANGES IN PREGNANCY

Objectives:

- Symptoms and physical findings of each organ system
- Physiologic versus pathologic changes
- Diagnostic tests and interpretations during physiological changes

Done by : Ghadah Aleissa , Sara Alkhalifah

Revised by: Haifa almohsen, lina alshehri



-There are many physiologic changes in pregnancy. Some mimic the signs, symptoms, or laboratory finding of disease in the nonpregnant woman yet are normal in pregnancy.

- Therefore , knowledge of normal maternal physiologic changes helps avoid unnecessary diagnostic or therapeutic interventions.

-Types of changes in pregnancy: -Hormonal -Mechanical

-Pregnant women should be educated about physiological changes in order to avoid complications.

1- hematologic :

Red blood cells mass and plasma volume	RBC mass increases by 20-35 %, while Plasma volume increases by 50-70 %. (It is not proportional increase)
WBC	Increase normally up to 16,000/mm ³ (up to 12 is accepted) more than 12 is pathological -Immunity is measured by IgG and IgM (slightly decrease during pregnancy) and not WBCs (slightly increase).
ESR	Increase in pregnancy because of the increase in gamma globulins.
Coagulation factors	Increase in Factors VI, VII,X, fibrinogen (no changes in II, V, XII) and fall in levels of active protein c, protein s, antithrombin III. hypercoagulable state that increase risk thromboembolic disease. You have to know which factors increase and which factors don't. PT, PTT, INR should not be affected by these changes.
Platelet	Slightly decrease still in the normal range but lower than expected. Healthy women 200-300 Pregnant women >150
hemoglobin	Hemoglobin stays the same in early pregnancy (12-16 g/dL) then it may drop down(normal range in pregnancy: 10-14 g/dL), so if the level become less than 10 g/dL we consider it anemia.
hematocrit	Decreased by 38-47% (normal pregnancy Hct is 32-42)
Plasma folate concentration	decreased
Peripheral vascular resistance	Decreased
Viscosity	Increased
D dimer	Increases. A useless test during pregnancy.

- Pregnancy is a hypercoagulable state (pregnant women have more chances of getting DVT and PE). This is why mobility is highly encouraged during pregnancy and postpartum period.
- The gravid uterus puts pressure on the IVC \uparrow stasis \rightarrow \uparrow DVTs
- Pregnant women are advised not to take long flights (>6-7 hours) after a certain time during pregnancy because it increases chances of DVT and PE.
- In healthy young women at least 2 CBCs are done during pregnancy.
- Binding proteins are decreased in pregnancy.

Physiologic anemia (dilutional anemia): \uparrow \uparrow plasma volume

- dilution because the plasma volume expands more than the erythrocyte volume.
- the oxygen-carrying capacity of the blood is **not deficient**.
- Red cell mass (driven by an increase in maternal erythropoietin production) also increases, but relatively less, compared with the increase in plasma volume.
- \uparrow \uparrow plasma volume \uparrow red cell volume
- Both plasma volume and red cell volume increase however, the increase is not proportional.

Pathological anemia:

- the oxygen-carrying capacity of the blood is **deficient** because of disordered erythrocyte production or excessive loss of erythrocytes through destruction or bleeding during pregnancy, anemia is defined as Hb < 10 g/dL (Hct < 30%).
- Anemia occurs in up to one third of women during the 3rd trimester
 - Causes:Iron deficiency anemia, Folate deficiency and hemoglobinopathies.
- Physiological anemia and iron deficiency anemia are common during pregnancy. You have to know the difference.
- In pregnancy a hemoglobin level of 10 is usually accepted. *check normal values in the anemia lecture

2- cardiovascular:

- Normal changes in heart sounds during pregnancy:
 - Increased loudness of both s1 and s2
 - Increased splitting of mitral and tricuspid components of s1
 - No constant changes in s2
 - Loud s3 by 20 weeks' gestation
 - <5% with s4
 - >95% develop systolic murmur which disappears after delivery
 - 20% have a transient diastolic murmur
 - 10% develop continuous murmurs due to increased mammary blood flow (increased blood flow to the breast)

- Uterus increases in size → pushes diaphragm → left axis deviation and ECG and Xray changes (changes in the costophrenic angle)

Cardiovascular Changes

- Heart rate increases (10-20%) Young healthy nonpregnant women around 70 bpm, in pregnant women it increases around 10 bpm, 3rd trimester heart rate will be around 95 bpm.
- Stroke volume increases (10%)
- Cardiac output increases (30-50%)
- Mean arterial pressure decreases (10%)
- Peripheral resistance decreases (35%) This is why many women complain of **postural hypotension**, dizziness. Instruct women to move slowly and hydrate.

*Arrhythmias are not physiological in pregnancy

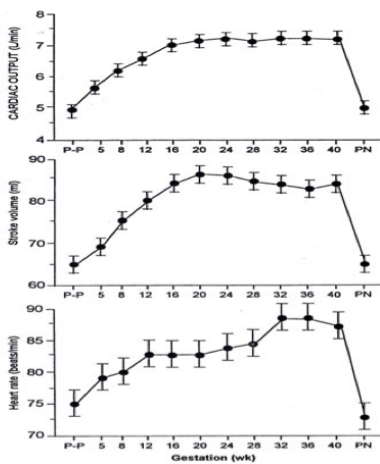
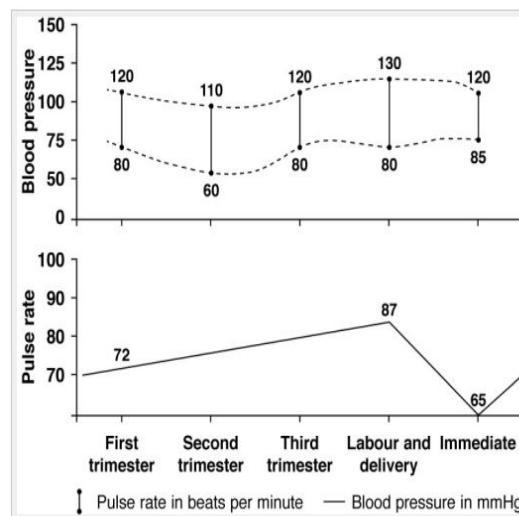


Figure 3-3. Increase in cardiac output from the nonpregnancy state throughout pregnancy. P-P, pre-pregnancy; PN, postnatal. (From Hunter S, Robson S: Adaptation of the maternal heart in pregnancy. Br Heart J 68:540, 1992, with permission.)



Left: Stroke volume and CO steadily increase during pregnancy. After delivery of the placenta the uterus contracts and the blood flow decreases, CO and stroke volume decrease suddenly.

Right: Blood pressure decreases during 1st trimester and it's at its lowest during the 2nd trimester. In the 3rd trimester it goes back to the same level as the 1st trimester. In all 3 trimesters blood pressure is lower (100-110/65-70, still in the normal range) than in the prepregnancy state.

*Encourage women to hydrate

Signs & Symptoms of Normal Pregnancy that may Mimic Heart Disease :

Signs

- Peripheral edema
 - Keep in mind that the pathological causes of edema DVT, nephrotic syndrome can still happen during pregnancy.
 - In the 3rd trimester some women experience upper limb edema

	<p>which can lead to carpal tunnel syndrome.</p> <ul style="list-style-type: none"> ● JVD
Symptoms	<ul style="list-style-type: none"> ● Reduced exercise tolerance ● Dyspnea
Auscultation	<ul style="list-style-type: none"> ● S3 gallop ● Systolic ejection murmur
Chest X-ray	<ul style="list-style-type: none"> ● Change in heart position & size ● Increased vascular markings
EKG	<ul style="list-style-type: none"> ● Nonspecific ST-T wave changes ● Axis deviation ● Slight LVH

3- respiratory:

-The major respiratory changes in pregnancy involve three factors: the mechanical effects of the enlarging uterus, the increased total body oxygen consumption, and the respiratory stimulant effects of progesterone.

-The diaphragm at rest rises to a level of 4 cm above its usual resting position. The chest enlarges in transverse diameter by about 2.1 cm. Simultaneously, the subcostal angle increases from an average of 68.5 degrees to 103.5 degrees during the latter part of gestation. **The increase in diameter doesn't help much with breathing because breathing depends more on the diaphragm rather than intercostal muscles.**

-As pregnancy progresses, the enlarging uterus elevates the resting position of the diaphragm.

- Mucosal hyperemia **pregnant women experience congestion and breathing becomes more irritable**
- Subcostal angle
- Chest circumference and diameter
- Tidal volume (+30-40%)
- PO₂ is increased (**increased demand. More O₂ goes to the uterus**), PCO₂ is decreased.
- Total lung capacity decrease (-15%)
- Minute ventilation (+30-40%)
- Mild respiratory alkalosis
- Respiratory rate increases **after exertion because of decreased lung capacity. If RR is very high think about PE.**

* O₂ consumption:

It Increases 15-20 %. (50 % of this increase is required by the uterus)

-Despite increase in oxygen requirements, with the increase in Cardiac Output and increase in alveolar ventilation oxygen consumption exceeds the requirements. Therefore, arteriovenous oxygen difference falls and arterial PCO₂ falls(hyperventilation cause mild respiratory alkalosis).

TABLE 6-3

LUNG VOLUMES AND CAPACITIES IN PREGNANCY

Test	Definition	Change in Pregnancy
Respiratory rate	Breaths/minute	No significant change
Tidal volume	The volume of air inspired and expired at each breath	Progressive rise throughout pregnancy of 0.1-0.2 L
Expiratory reserve volume	The maximum volume of air that can be additionally expired after a normal expiration	Lowered by about 15% (0.55 L in late pregnancy compared with 0.65 L postpartum)
Residual volume	The volume of air remaining in the lungs after a maximum expiration	Falls considerably (0.77 L in late pregnancy compared with 0.96 L postpartum)
Vital capacity	The maximum volume of air that can be forcibly inspired after a maximum expiration	Unchanged, except for possibly a small terminal diminution
Inspiratory capacity	The maximum volume of air that can be inspired from resting expiratory level	Increased by about 5%
Functional residual capacity	The volume of air in lungs at resting expiratory level	Lowered by about 18%
Minute ventilation	The volume of air inspired or expired in 1 min	Increased by about 40% as a result of the increased tidal volume and unchanged respiratory rate

4- renal:

- Renin secretion stimulated by progesterone and also it's produced by placenta, that lead to increase secretion of aldosterone which cause absorption of Na⁺ and water and excretion of K⁺ (still in the normal range). (Water retention: 6-8 liters)

- Increased renal blood flow(50-75%) will increase GFR (50%) that enhance the clearance of creatinine, urea, albumin and uric acid. So, Plasma creatinine, urea, albumin and urate are reduced. This is why pregnant women need to go to the bathroom more often.

- there is Increase in kidney size, dilation of pelvis and calyces due to increase in renal blood flow. Ureteral diameter (Rt>Lt) increases due to relaxation effect of progesterone to smooth muscles. Urinary stasis is a risk of UTI. Mild pyelectasis is sometimes seen.

-The hyperventilation (low P_aCO₂) of pregnancy results in respiratory alkalosis, which is compensated by renal excretion of bicarbonate. As a result, maternal renal buffering capacity is reduced.

-glucosuria is normally increases in pregnancy (we do not depend on it in the diagnosis of gestational diabetes). However, if glucose is always positive think about DM.

5- Endocrine:

Pituitary gland	<ul style="list-style-type: none"> - ↓ FSH and LH. - ↑ ACTH, Thyrotrophin, melanocyte hormone and prolactin. -Prolactin level ↑ until the 30th week of pregnancy then more slowly to term. Some women secrete breast milk during pregnancy - pituitary gland ↑ in size up to 3 folds in pregnancy which make the gland susceptible to ischemic injury (sheehan syndrome).
Adrenal gland	<ul style="list-style-type: none"> -Adrenal size is unchanged but total corticosteroids ↑ progressively to term. This will ↑ the tendency of pregnant women to develop abdominal striae, glycosuria, hypertension and gestational diabetes. -CRH from placenta stimulates ACTH production.
Thyroid gland	<ul style="list-style-type: none"> -Enlarges during pregnancy, occasionally to twice its normal size. This is mainly due to colloid deposition caused by a lower plasma level of iodine, consequent on the increased ability of the kidneys to excrete it during pregnancy. Enlarged thyroid during clinical examination is not normal - ↑ thyroid binding globulin (estrogen effect). - ↑ in total T3 and T4 although free T3, free T4 remain unchanged. When you want to test thyroid ask for free T3 and T4 and not total. Remember that binding proteins increase during pregnancy. -HCG suppresses TSH. Both have similar alpha subunits.
pancreas	Insulin resistance because of Human placental lactogen, cortisol

6- Gastrointestinal:

- Morning sickness (proportional to HCG level).
- Hyperemesis gravidarum (morning sickness): (weight loss, ketonemia and electrolyte imbalance) **during first trimester. Due to rapid increase of HCG levels.**
- Dietary craving: pica¹ وحم
- Displacement of the stomach, intestines and appendix. The appendix can be displaced to reach the right flank **due to compression by the uterus. Keep appendicitis in mind in acute abdomen.**
- Liver produces high amount of Coagulation factors and binding proteins of (thyroid, steroid, vitamin D).
- Gallbladder function → cholestasis
- Hyperemia, vascular swelling and softening of the gums (epulis) **bleeding of gums due to hyperemia**

¹ Pica is the practice of craving substances with little or no nutritional value. Most pregnancy and pica related cravings involve non-food substances such as dirt or chalk.

* Decreased gastrointestinal motility due to progesterone leading to:

- Nausea and vomiting
- Ptyalism: increase salivation
- Heartburn (GERD due to relaxation of LES)
- Hemorrhoid (also due to elevated pressure in veins) due to pressure by the uterus
- constipation.
- Prolonged gallbladder emptying time may lead to gallstones.(Bile salt buildup may lead to itching.)

7- MSK:

A woman's foot can grow by a half size or more during pregnancy, the increased body weight of pregnancy, fluid retention, and weight gain lowers the arches of the foot, further adding to the foot's length and width.

-The influences of increased hormones such as estrogen and relaxin initiate the remodeling of soft tissues, cartilage and ligaments. Certain skeletal joints such as the pubic symphysis and sacroiliac widen or have increased laxity.

- Lumbar lordosis.

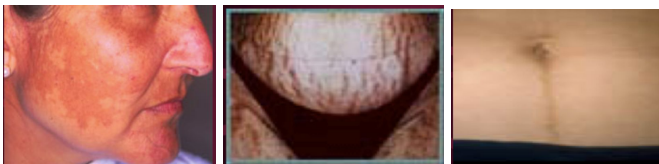
*ALP is doubled in pregnancy because of increased production by the placenta

8- Skin:

A- Chloasma or melasma gravidarum

B- Striae

C- Linea nigra



A

B

C

-Women tend to have increased pigmentation during pregnancy. This is why they're advised against receiving laser treatments.

Weight changes:

-The average weight gain in pregnancy uncomplicated by generalized edema is 12.5 kg (28 lb). (This increase mainly occur in **second trimester**)

- Weight changes during pregnancy: 12-18 kg
 - Uterine muscle (majority)
 - Breast enlargement
 - Fluid retention

- The products of conception constitute only about 40% of the total maternal weight gain

Where do the pregnancy Kilos go?	
Maternal stores of nutrients and muscle development	3 Kg
Increased body fluid	2 Kg
Increased blood	1.5 - 2 Kg
Breast growth	600g
Enlarged uterus	1 Kg
Amniotic fluid	1 Kg
Placenta	600g
Baby	3.4 - 4 Kg
Total	11 - 16 Kg

Healthy weight gain during pregnancy		
Pre-pregnancy BMI	Weight gain in kilograms	Weight gain in pounds
Underweight (under 18.5 BMI)	12.5-18	28-40
Normal weight (18.5-25 BMI)	11.5-16	25-35
Overweight (25-30 BMI)	7-11.5	15-25
Obese	5-9	11-20

TRISH MALASTER / THE GLOBE AND MAIL
SOURCE: U.S. INSTITUTE OF MEDICINE



Anatomical changes:

Breast:

Engorgement and venous prominence.

-**Mastodynia** (breast tenderness): tingling to frank pain caused by hormonal responses of the mammary ducts and alveolar system.

- **Montgomery's tubercles**: enlargement of circumlacteal sebaceous glands of the areola

-**Colostrum secretion**.



Montgomery's tubercles

Uterus :

The uterus undergoes an enormous increase in weight from the 50g- 70g nonpregnant size to approximately 950g at term, primarily through hypertrophy of existing myometrial cells.

- Also, the uterine cavity, which in the nongravid state has a volume of less than 10 ml, increases up to as much as 5 liters.
- The uterine blood vessels also undergo hypertrophy and become increasingly coiled in the first half of pregnancy but no further growth after that.
- The lower uterine segment is that part of the lower uterus and upper cervix lying between the line of attachment of the peritoneum of the uterovesical pouch superiorly and the histological internal os inferiorly

Cervix:

-Becomes softer and swollen in pregnancy (doesn't change in size only becomes more swollen), with the result that columnar epithelium lining the cervical canal becomes exposed to the vaginal secretions.

-Prostaglandins act on the collagen fibres, especially in the last week of pregnancy. At the sometime collagenase is released from leucocytes, which also helps in breaking down collagen. The cervix becomes softer and more easily dilatable the so called ripening of the cervix.

VAGINA:

-The vaginal mucosa becomes thickness, the vaginal muscle hypertrophins.

-There is alteration in the composition of the connective tissue, with the result that the vagina dilates more easily to accommodate the fetus during labor.

-Oestrogen desquamation of the superficial vaginal mucosal cells with in vaginal discharge when pathogenesis entre the vagina (candida, trichomas) they will flourish rapidly.



1) In a normal cardiovascular adaptation during pregnancy. Which of the following tend to decrease?

- A- Blood volume
- B- Cardiac output
- C- Heart rate
- D- Peripheral resistance

2) Which of the following parameters will be decreased in a normal pregnancy??

- A. fibrinogens
- B. peripheral vascular resistance
- C. plasma volume
- D. Red blood mass

3) How much does the glomerular filtration rate increases during pregnancy?

- A- 25%
- B- 50%
- C- 100%
- D- 78%

Answers: 1) d 2) b 3) b