

433 Teams

OBSTETRICS & GYNECOLOGY

Physiological Changes During Pregnancy

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Objectives:

- Discuss the maternal physiologic and anatomic adaptation to pregnancy related to the following:
 - ✓ Cardiovascular system
 - ✓ Respiratory system
 - ✓ Renal system
 - ✓ Endocrine system
 - ✓ Weight gain
- Describe the mechanisms of maternal and-fetal transfer of substances across the placenta.
- Discuss the properties, functions and interactions of pregnancy related hormones.

Introduction

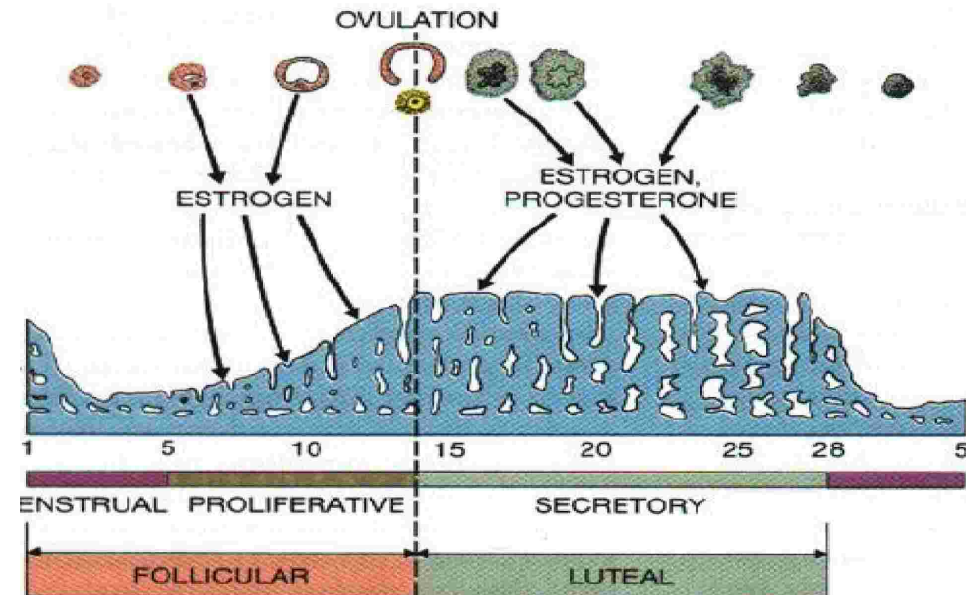
- There are many **physiologic changes in pregnancy**. Some mimic the signs, symptoms, or laboratory finding of disease in the nonpregnant woman **yet are normal in pregnancy**.
- Therefore, knowledge of normal maternal physiologic changes helps avoid unnecessary diagnostic or therapeutic interventions.

The **normal adaptations** that a woman undergoes during pregnancy to better accommodate the embryo or fetus, include:

- A. Cardiovascular
- B. Hematologic
- C. Metabolic
- D. Renal
- E. Respiratory

Hormonal changes

- **Estrogen** is mainly produced by the placenta and is associated with fetal well-being.
- Women also experience increased human chorionic gonadotropin (**β -hCG**); which is produced by the placenta. This maintains progesterone production by the corpus luteum.
- The increased **progesterone** production, **first by corpus luteum and later by the placenta, functions to relax smooth muscle.**
- Elevated progesterone levels also contribute to an increase in **minute ventilation** to 50% greater than non-pregnant levels.



Up to the **6th or 7th week** of pregnancy, the major source of **progesterone** (in the form of 17-OH progesterone) is the **ovary**. Thereafter, the **placenta** begins to play the major role.

For the first **6 to 8 weeks** of pregnancy, **hCG** maintains the corpus luteum and thereby ensures continued progesterone output until progesterone production shifts to the placenta.

Hormonal changes

- **Prolactin** levels **increase** due to **maternal pituitary gland enlargement** by 50%.
 - ✓ This mediates a change in the structure of the mammary gland from ductal to lobular-alveolar.
- **Human placental lactogen (hPL)** is produced by the **placenta** and stimulates **lipolysis and fatty acid metabolism** by the woman, conserving blood glucose for use by the fetus.
 - ✓ It can also decrease maternal tissue sensitivity to insulin, **resulting in gestational diabetes**.

Human placental lactogen antagonizes the cellular action of insulin and decreases maternal glucose utilization, which increases glucose availability to the fetus.

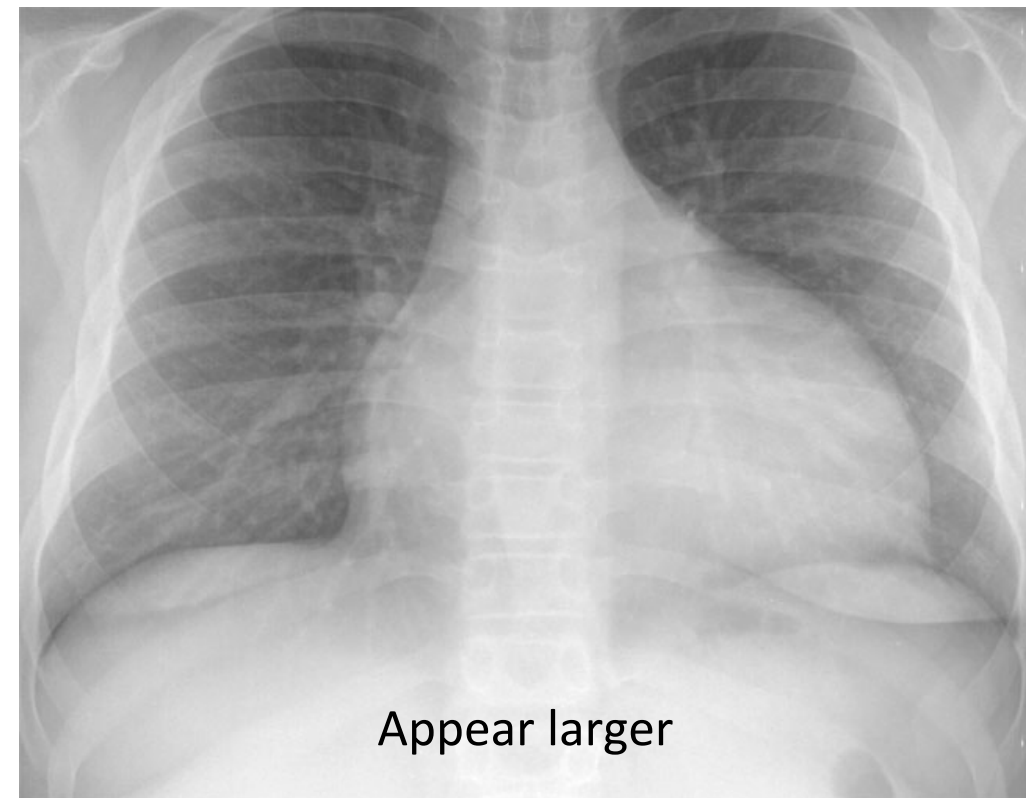
Hormonal changes

- **Parathyroid hormone** is **increased** which leads to increases of calcium uptake in the gut and reabsorption by the kidney.
- **Adrenal hormones** such as cortisol and aldosterone also **increase**.
- **Thyroid hormones:**
 - ✓ Thyroid enlargement
 - ✓ High level **total** T3,T4
 - ✓ **Normal TSH**
 - ✓ Subclinical hypothyroidism

Thyroxine-binding globulin (TBG) is increased during pregnancy because the high estrogen levels induce increased hepatic synthesis. The body responds by **raising total** circulating levels of T4 and T3, and the net effect is that the **free, biologically active** concentration of each hormone is **unchanged**.

Cardiovascular changes

- **Position and size of heart:** As the uterus enlarges and the diaphragm becomes elevated, the heart is displaced upward and somewhat to the left with rotation on its long axis, so that the apex beat is moved laterally to the left).
- **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

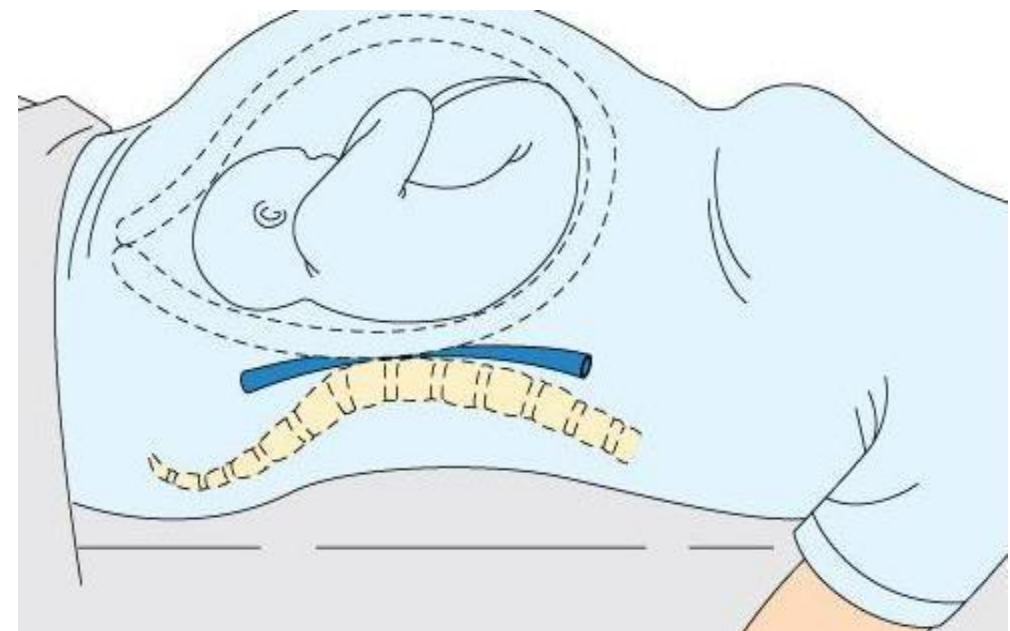


Cardiovascular changes

- **Murmurs:**
 - ✓ **Systolic** ejection murmur along the left sternal border is **normal in pregnancy**
 - ✓ Diastolic murmurs are never normal in pregnancy and must be investigated.

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.



Cardiovascular changes

- **Blood volume** slowly **increases** by 40-50%.

The increase is mainly due to an increase in **plasma volume** through increased aldosterone (**Dilutional anemia**). It results in an increase in heart rate (**15 beats/min more than usual**), stroke volume, and cardiac output.

- **Cardiac output** **increases** by about 50%, mostly during the first trimester.
- The **systemic vascular resistance** also slightly **decreases** due to **smooth muscle relaxation and overall vasodilation caused by elevated progesterone**.
- **Diastolic blood pressure** consequently **decreases**.
 - ✓ If the blood pressure becomes abnormally high, the woman should be investigated for pre-eclampsia and other causes of hypertension.

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%

Hematologic system

Blood volume	+40%
Dilutional anemia	Hb 110 g/L
Leukocytosis	15,000/ml
Sedimentation rate	increase, 100m/h
Platelet	no change

Clotting factors: hypercoagulable, throboembolism

Fibrinogen (factor I)	+50% (4.5 vs 3 g/L)
Factor VIII, VII, IX, X and XII	increase
Prothrombin time, PT	shortened
activated partial thromoplastin time	
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.

Pulmonary changes

- Mucosal hyperemia
- Subcostal angle
- Chest circumference and diameter
- **Tidal volume (+30-40%)**
- PO_2 is increased, PCO_2 is decreased.
- Total lung capacity decrease (-15%)
- **Minute ventilation (+30-40%)**
- Mild **respiratory alkalosis**

Gastrointestinal change

- Morning sickness
 - ✓ **Hyperremesis gravidarum** : (weight loss, ketonemia and electrolyte imbalance)
- Dietary craving: pica
- Decreased gastrointestinal motility → reflux, heartburn and constipation.
- Gallbladder function → cholestasis
- Hyperemia and softening of the gums (epulis)
- Hemorrhoid
- Appendix displaced

Renal changes

Kidney	Slightly enlarged
Renal plasma flow	+35%
Glomerular filtration rate	+50%
Serum creatinine, uric acid urea and nitrogen	↓
Renin, angiotensin I and II Renin substrate	↑
Glucosuria	+50%

Renal pelvis	Dilated
Ureters (esp. right side)	
Bladder tone	Reduced (stasis → increase risk of UTI)
Bladder capacity	
Residual volume	Increased
Chance of pyelonephritis	

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.

Breasts

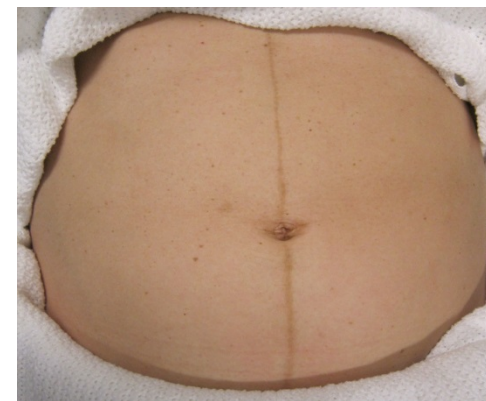
- Engorgement and venous prominence.
- **Mastodynia (breast tenderness):** tingling to frank pain caused by hormonal responses of the mammary ducts and alveolar system
- **Montgomery's tubercles:** enlargement of circumlacteal sebaceous glands of the areola
- **Colostrum secretion**



Montgomery's tubercles

Skin changes

- Vascular spiders
- Striae gravidarum
- Hyperpigmentation (estrogen and melanocyte-stimulating hormone)
 - ✓ linea nigra: Linea alba
 - ✓ Chloasma : Face Mask
- Skin nevi



linea nigra



Chloasma

Reproductive tract

- The **uterus** undergoes an enormous increase in **weight** from the **50g- 70g nonpregnant size to approximately 1100g 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**.
- **Cardiac output to the uterus** is less than 2% in the nongravid state, but increases to **15%-20% at term**.

Reproductive tract

- **Braxton Hicks contraction:** sporadic, irregular, asymmetrical, and painless, low pressure, lasting < 30 sec.

Characteristics of True and False Labor

True Labor	False Labor
<ul style="list-style-type: none">○ Regular Contractions○ Stronger, longer, closer together○ Bloody show often present○ Cervix effaced and dilated○ Head is fixed between contractions○ Sedation does not stop true labor	<ul style="list-style-type: none">○ Irregular○ No change in contraction characteristics○ No show○ No cervical change○ Head may be ballotable○ Sedation stops false labor

Reproductive tract

- **Cervix and vulva** , **Chadwick's sign**: congestion of the pelvic vasculature, cause bluish or purplish discoloration of the cervix and vulva
- **Leukorrhea**: increase in vaginal discharge, rich in glucose, lactic acid, low vaginal pH
- **Ovary**: slightly enlarged, corpus luteum regresses after 10 -12 weeks' gestation

Metabolism

- Basal metabolism rate, BMR
- Weight gain
- Insulin resistance

+15-20%
12.5kg

Fetus	3400g
Placenta	650g
Amniotic	800g
Uterus	960g
Plasma, red cells	1450g
Mammary glands	405g
Extracellular, extravascular water	1480g
Deposition of fat and protein	3345g

Musculoskeletal

- 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.**

Immune system

- the immune system significantly changes during pregnancy and these changes are essential for normal placentation and maintenance of a healthy pregnancy
- pregnant women are **more sensitive to certain infections**
- This raises questions on the safety of vaccination during pregnancy



Lumbar lordosis

The degree and mechanism of placental transfer of the substances:

MATERNAL-FETAL TRANSFER DURING PREGNANCY		
Function	Substance	Placental Transfer
Glucose homeostasis	Glucose	Excellent—"facilitated diffusion"
	Amino acids	Excellent—active transport
	Free fatty acids (FFA)	Very limited—essential FFA only
	Ketones	Excellent—diffusion
	Insulin	No transfer
	Glucagon	No transfer
Thyroid function	Thyroxine (T ₄)	Very poor—diffusion
	Triiodothyronine (T ₃)	Poor—diffusion
	Thyrotropin-releasing hormone (TRH)	Good
	Thyroid-stimulating immunoglobulin (TSI)	Good
	Thyroid-stimulating hormone (TSH)	Negligible transfer
	Propylthiouracil	Excellent
Adrenal hormones	Cortisol	Excellent transfer and active placental conversion of cortisol to cortisone beginning at mid-pregnancy*
	ACTH	No transfer
Parathyroid function	Calcium	Active transfer against gradient
	Magnesium	Active transfer against gradient
	Phosphorus	Active transfer against gradient
	Parathyroid hormone	Not transferred
Immunoglobulins	IgA	Minimal passive transfer
	IgG	Good—both passive and active transport from 7 wk gestation
	IgM	No transfer

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