LEARNING OBJECTIVES

» Describe the normal anatomical and physiologic changes of pregnancy

» Prerequisites:
  » NONE

» See also – for closely related topics
  » FLAME LECTURE 24: Normal maternal cardiovascular changes of pregnancy
  » FLAME LECTURE 25: Normal maternal respiratory changes of pregnancy
ANATOMICAL CHANGES IN PREG

- **Vagina & Cervix**
  - Vaginal erythema (Chadwick’s sign) and cervix have bluish discoloration (Goodell’s sign)
  - The mucous membranes of the vulva, vagina, and cervix become congested, beginning at about 8 to 12 weeks of gestation
  - Cervix becomes soft
  - Despite softening, normal cervical length of >3.5 cm should be maintained during pregnancy
    - Thinning of cervix < 2.5 cm signifies risk of preterm delivery

- **Breasts**
  - Become fuller and tender
  - Areola darkens and the veins under the breast skin become more visible
ANATOMICAL CHANGES IN PREG

- **Uterus**
  - 4 weeks: Enlarged and globular, increasing in size by about 1 cm per week
  - 6 weeks: Uterus softens
  - 12 weeks: uterus is sufficiently large to palpate abdominally just above the pubic symphysis
  - 20 weeks: top of the uterus is at the umbilicus
  - > 20 weeks: fundal height can be used as measurement of GA by measuring distance from pubic symphysis to top most palpable edge of uterus. GA = Fundal height (cm) ± 2
  - By end of 3rd trimester, uterus is palpable just below ribcage
ANATOMICAL CHANGES IN PREG

- Other anatomical changes
  - **Lungs**: lungs and diaphragm progressively compressed → VC and TLC decreased late in pregnancy
  - **Stomach**: compressed by growing uterus → difficult to eat large meals, increased reflux
  - **Bladder**: compressed from behind/above by growing uterus → increased urinary frequency
  - **MSK**: hormone *relaxin* secreted by placenta causes pelvic ligaments and pubic symphysis to become more flexible, widening and relaxing
Cardiovascular Changes

See FLAME LEC 24 for more info

- **Cardiac output** = HR x SV (stroke volume; volume of blood pumped from the left ventricle with each heart beat). 3 major factors that affect SV include:
  - **Preload**: the degree to which the ventricles are stretched prior to contracting; determined primarily by the volume and speed of venous return
  - **Contractility**: largely affected by sympathetic and parasympathetic interplay
  - **Afterload**: the aortic pressure during systole (systolic blood pressure); governed by vascular resistance

- **Cardiac output INCREASES** by 43% during pregnancy
  - This increase is driven in the 1st tri primarily by ↓ vascular resistance (-21%), and later in pregnancy by ↑ plasma volume (+40%–50%) and heart rate (+17%)
CARDIOVASCULAR CHANGES IN LABOR

- **Stage I**
  - Pain, anxiety, and contractions ↑s HR, SV, and CO by a further 50%
  - Supine positioning causes compression of IVC → ↓ preload and thus ↓ CO

- **Stage II**
  - Valsalva and relaxation with pushes ↑s and ↓s preload, respectively
    - These fluctuations in CVP during labor may effectively be attenuated by adequate pain control, minimization/avoidance of valsalva, and assisted delivery

- **Stage III**
  - Blood loss following delivery can ↓ preload
  - There can also be an ↑ in preload by the autotransfusion of ~500 cc of blood that returns to systemic circulation following delivery of the placenta
HEMATOLOGIC CHANGES

Erythrocytes
- Plasma volume INCREASES by nearly 50%
- Red blood cell mass INCREASE by 20-30%
  - This discrepancy in increases results in *dilutional anemia* of pregnancy (nadir 30-34 weeks)

Lymphocytes
- WBC count INCREASES to new normal of 9-15,000
  - During labor, there can be a transient, asymptomatic increase in WBC’s to ~20k, not associated with fevers

<table>
<thead>
<tr>
<th>Avg levels</th>
<th>Non-Pregnant</th>
<th>Pregnant</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hemoglobin (g/dL)</td>
<td>12-14</td>
<td>10-12</td>
</tr>
<tr>
<td>RBC count</td>
<td>4.2</td>
<td>3.7</td>
</tr>
<tr>
<td>Hematocrit</td>
<td>40%</td>
<td>34%</td>
</tr>
<tr>
<td>MCV (fl)</td>
<td>75-99</td>
<td>80-103</td>
</tr>
<tr>
<td>WBC (x10⁹/L)</td>
<td>4-11</td>
<td>9-15</td>
</tr>
<tr>
<td>Platelets (x10⁹/L)</td>
<td>140-440</td>
<td>100-440</td>
</tr>
<tr>
<td>ESR (mm/h)</td>
<td>&lt;10</td>
<td>30-100</td>
</tr>
</tbody>
</table>
HEMATOLOGIC CHANGES

Platelets

- Mild thrombocytopenia
- Pregnancy is a **hypercoagulable state**
  - Thought to have developed to prevent post-partum hemorrhage
  - Increased fibrinogen and clotting factors, decreased anticoagulant Protein S
- Normal clotting/bleeding times
- Decreased fibrinolysis
- Other aspects of Virchow’s triad including venous stasis
- Therefore, increased risk of VTE’s during pregnancy
RESPIRATORY CHANGES
See FLAME LEC 25 for much much more detail

- Pregnant women often experience nasal stuffiness and epistaxis
  - Some women develop benign growths called nasal granuloma gravidarum, pregnancy tumor, pregnancy granuloma, or telangiectatic polyp
- “Barrel-Chested” appearance due to increasing chest diameter and elevation of the diaphragm
- Increased minute ventilation – women will report feelings of dyspnea
  - INCREASE tidal volume
  - DECREASE total lung capacity late in pregnancy
- Oxygen consumption increases 20%
  - PaO2 increases and PaCO2 decreases causing a physiologic respiratory alkalosis which promotes oxygen release for increased fetal oxygenation
**RENAAL/URINARY CHANGES**

**Intra-renal**
- Glomerular filtration rate (GFR) rises 40-50%
  - And thus ↑ excretion of BUN, creatinine, uric acid, protein, glucose
  - Decrease in the serum anion gap

**Extra-renal**
- Both kidneys increase in size by 1 to 1.5 cm
- Kidney volume increases by up to 30%
- Dilatation of the ureters and renal pelvis (hydroureter and hydronephrosis) is more prominent on the right than the left and is seen in up to 80% of pregnant women
  - Increased risk for pyelonephritis due to ureter dilation and glycosuria
GI CHANGES

- Gastrointestinal secretion and absorption remains unchanged
- Gastrointestinal motility DECREASES
- Taste perception can change
- Gingival inflammatory symptoms are frequently aggravated during pregnancy
- Gastroesophageal reflux is common
  - Pregnant women are predisposed to gastric aspiration due to increased intraabdominal pressure and relaxation of the lower esophageal sphincter (progesterone-mediated)
- Total cholesterol + triglycerides INCREASE
- Pregnancy decreases gallbladder motility and increases the lithogenicity of bile → increased risk of cholelithiasis
- Constipation, incontinence, and hemorrhoids, are common during pregnancy and postpartum
# Endocrine Changes

<table>
<thead>
<tr>
<th>INCREASES</th>
<th>DECREASES</th>
<th>UNCHANGED</th>
</tr>
</thead>
<tbody>
<tr>
<td>GnRH</td>
<td>Gonadotropins</td>
<td>GHRH</td>
</tr>
<tr>
<td>CRH</td>
<td>PTH decreases 1st ½ of pregnancy, then increases</td>
<td>TRH</td>
</tr>
<tr>
<td>ACTH</td>
<td>Thyroid stimulating hormone</td>
<td>ADH</td>
</tr>
<tr>
<td>T3 and T4</td>
<td></td>
<td></td>
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<tr>
<td>Melanocyte stimulating hormone</td>
<td></td>
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<tr>
<td>Oxytocin</td>
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<tr>
<td>Aldosterone</td>
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<tr>
<td>Progesterone</td>
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<tr>
<td>Estradiol</td>
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<tr>
<td>Prolactin</td>
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**ENDOCRINE CHANGES**

- **Thyroid**
  - Size increases with follicular hyperplasia
  - TSH decreases in early pregnancy and returns to normal in the third trimester
  - Estrogen $\rightarrow$ ↑ thyroid binding globulin = ↑ TT3 and TT4 (50% > NL range)
    - However, NORMAL free T3 and free T4. Thus, pregnancy is euthyroid state
  - TSH, T4 and T3 do not cross the placenta
  - TRH, thyroid stimulating immunoglobulins cross placenta
Placental hormones

- Placenta secretes estrogen, β-hCG and hPL
  - β-hCG: α-subunit is same as α-subunit in TSH, FSH, and LH
    - Can have thyroid and ovarian stimulating effect
    - Peaks around 10wks at ~100K
    - Responsible for maintenance of corpus luteum allowing for continued secretion of progesterone
  - Human placental lactogen (hPL): maintains fetal nutrition
    - Increases lipolysis and insulin resistance so more glucose delivered to placenta
**METABOLIC CHANGES**

- Maternal metabolism switches in late pregnancy from carbohydrate to fat utilization (free fatty acids, ketones and glycerol)
- Human placental lactogen secretion results in:
  - Insulin resistance & increased insulin secretion
  - Increased plasma concentrations of lipolytic hormones
- Carbohydrate metabolism in the later part of pregnancy is directed toward supplying glucose and amino acids to the growing fetus
- Fasting glucose concentrations decreases 10% to 20%
  - Increased storage of tissue glycogen
  - Increased peripheral glucose utilization
  - Decreased hepatic glucose production
  - Glucose consumption by the fetus (especially in late pregnancy)
- Water retention with an average increase at term of 3 liters
MUSCULOSKELETAL CHANGES

- Lordosis of the lower back, forward flexion of the neck, and downward movement of the shoulders occur to compensate for the enlarged uterus and change in center of gravity
  - Lordosis + ligament laxity can lead to lower back strain
- Laxity of the spinal longitudinal ligaments, widening and increased mobility of the sacroiliac joints, and pubic symphysis laxity are all mediated by relaxin
- Significant increase in the anterior tilt of the pelvis and increased use of hip extensor, abductor, and ankle plantar flexor muscles
- Fluid retention can cause compression of certain structures
  - Compression of the median nerve by edema can lead to self-limiting carpel tunnel syndrome

<table>
<thead>
<tr>
<th>Women Gain</th>
<th></th>
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<tbody>
<tr>
<td>Normal BMI</td>
<td>25-30lbs</td>
</tr>
<tr>
<td>Overweight BMI</td>
<td>15-25lbs</td>
</tr>
<tr>
<td>Obese BMI</td>
<td>11-20lbs</td>
</tr>
</tbody>
</table>

Sacroiliac joint instability

Gap increases by 1cm or more
DERMATOLOGIC CHANGES

- Hyperpigmentation normally in discrete, localized areas
  - Almost all pregnant women develop some degree of increased skin pigmentation
  - Most frequent: darkening of the linea alba, becoming the linea nigra
  - Melasma, hyperpigmentation of face, occurs in up to 75% pregnant women
    - Worsened by sun exposure
    - Due to increased melanocyte stimulating hormone and steroid hormones
  - Striae gravidarum (stretch marks) begin as pink/violaceous linear patches in the 6th to 7th month of gestation
DERMATOLOGIC CHANGES

- Estrogen can cause vascular distention and instability, and proliferation of blood vessels during pregnancy
  - Spider telangiectasias
  - Palmar erythema
  - Saphenous, vulvar, and hemorrhoidal varicosities all occur at an increased rate during pregnancy and cannot be prevented
- Pruritus commonly affects pregnant women, due to variety of causes
  - Pruritic urticarial papules and plaques of pregnancy (PUPPP): often starts periumbilical or along abdominal striae, face spared – oral antihistamines / topical steroids
  - Prurigo of pregnancy: erythematous papules on extensor surfaces of extremities – oral antihistamines / topical steroids
  - Intrahepatic cholestasis of pregnancy: pruritic palms – oral antihistamines / ursodiol
DERMATOLOGIC CHANGES

- **Hair Changes:**
  - Hirsutism: male-pattern hair growth most frequently on the face, but may also be seen on the arms, legs, back, and suprapubic region
  - Scalp hair appears thicker or denser

- **Nail Changes:**
  - Nails grow faster during gestation, but can become dystrophic with transverse grooves, subungual keratosis, and distal onycholysis
  - Nail plate may become soft or brittle
REFERENCES


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8. UpToDate: “Musculoskeletal Changes and Pain During Pregnancy and Postpartum”
9. UpToDate: “Hematologic Changes in Pregnancy”
10. UpToDate: “Immunology of the Maternal-Fetal Interface”