



# BASIC ANATOMY & PHYSIOLOGY OF PREGNANCY

FLAME LECTURE: 22

LO 5.2.18

# 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.  $GA = \text{Fundal height (cm)} \pm 2$
- ▶ By end of 3<sup>rd</sup> trimester, uterus is palpable just below ribcage

# ANATOMICAL CHANGES IN PREG

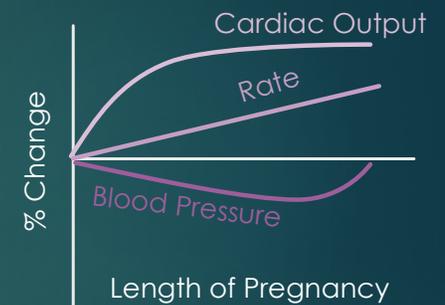
## ▶ Other anatomical changes

- ▶ **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 =  $HR \times SV$  (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 1<sup>st</sup> 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* (nadirs 30-34 weeks)

## Lymphocytes

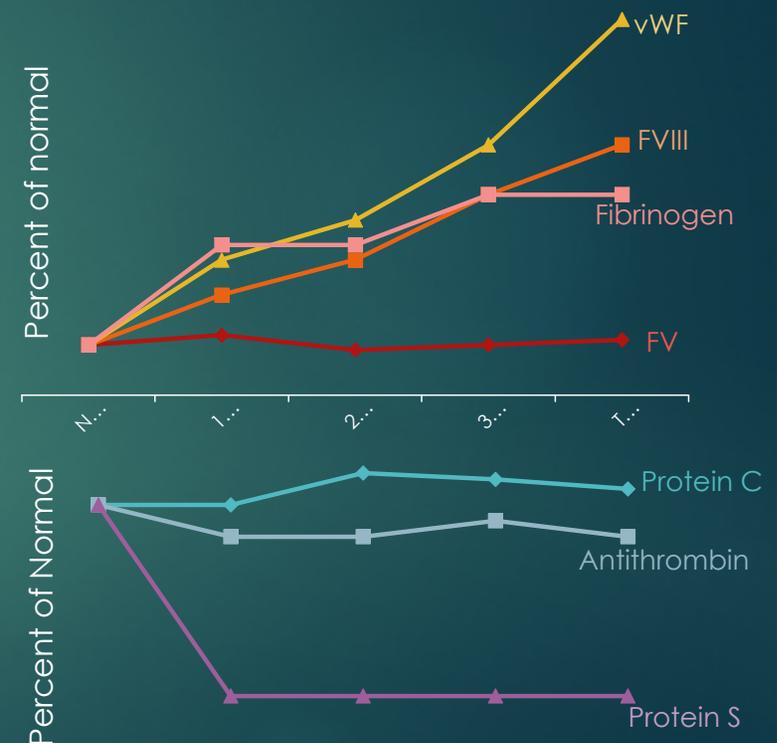
- ▶ WBC count INCREASES to new normal of 9-15,000
  - ▶ During labor, there can be a transient, asymptomatic increase in WBC's to ~20k, not associated with fevers

Avg levels	Non-Pregnant	Pregnant	
Hemoglobin (g/dL)	12-14	10-12	↓
RBC count	4.2	3.7	↓
Hematocrit	40%	34%	↓
MCV (fl)	75-99	80-103	↑
WBC (x10 <sup>9</sup> /L)	4-11	9-15	↑
Platelets (x10 <sup>9</sup> /L)	140-440	100-440	↓
ESR (mm/h)	<10	30-100	↑

# 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%
  - ▶ PaO<sub>2</sub> increases and PaCO<sub>2</sub> decreases causing a physiologic *respiratory alkalosis* which promotes oxygen release for increased fetal oxygenation

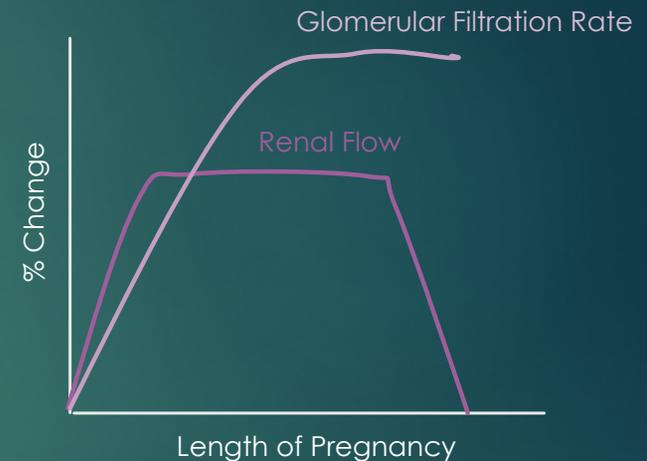
# RENAL/URINARY CHANGES

## 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

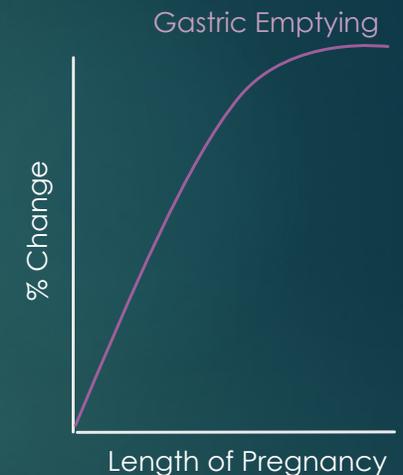
## Extra-renal

- ▶ 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

INCREASES	DECREASES	UNCHANGED
GnRH	Gonadotropins	GHRH
CRH	PTH decreases 1st ½ of pregnancy, then increases	TRH
ACTH	Thyroid stimulating hormone	ADH
T3 and T4		
Melanocyte stimulating hormone		
Oxytocin		
Aldosterone		
Progesterone		
Estradiol		
Prolactin		

# ENDOCRINE CHANGES

## ▶ Thyroid

- ▶ Size increases with follicular hyperplasia
- ▶ TSH decreases in early pregnancy and returns to normal in the third trimester
- ▶ Estrogen → ↑ 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

# ENDOCRINE CHANGES

## Placental hormones

- ▶ Placenta secretes estrogen,  $\beta$ -hCG and hPL
  - ▶  $\beta$ -hCG:  $\alpha$ -subunit is same as  $\alpha$ -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 carpal tunnel syndrome

## Women Gain

Normal BMI	25-30lbs
Overweight BMI	15-25lbs
Obese BMI	11-20lbs



**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 6<sup>th</sup> to 7<sup>th</sup> month of gestation



MELASMA



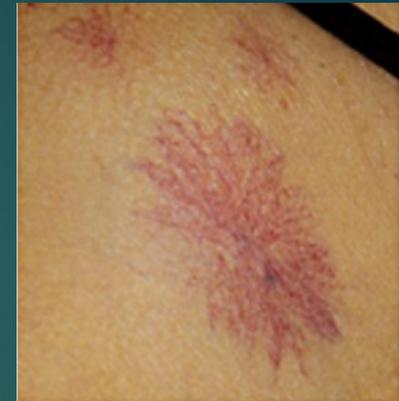
LINEA NIGRA



STRIAE GRAVIDARUM

# DERMATOLOGIC CHANGES

- ▶ Estrogen can cause vascular distention and instability, and proliferation of blood vessels during pregnancy
  - ▶ Spider telangectasias
  - ▶ 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



SPIDER TELANGECTASIA



PUPPPS

# 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

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