Physiologic Changes in Pregnancy

General Principles

- Most changes begin early
  - Even before pregnancy recognized
- Most are hormonally driven
  - Progesterone, estrogen, renin / aldosterone, cortisol, insulin
  - Some ‘mechanically’ driven
- Designed to optimize conditions for fetus & prepare for delivery
  - Delivery of oxygen & nutrients

Cardiovascular & Hematologic

- Vascular
  - Decreased tone / vaso-relaxation
    - SVR decreased **20%**
  - Positional effects
  - Placenta – low resistance shunt
- Hematologic
  - Blood volume increases 50-100%
  - RBC increases 25-40%
    - Relative anemia (“physiologic”)

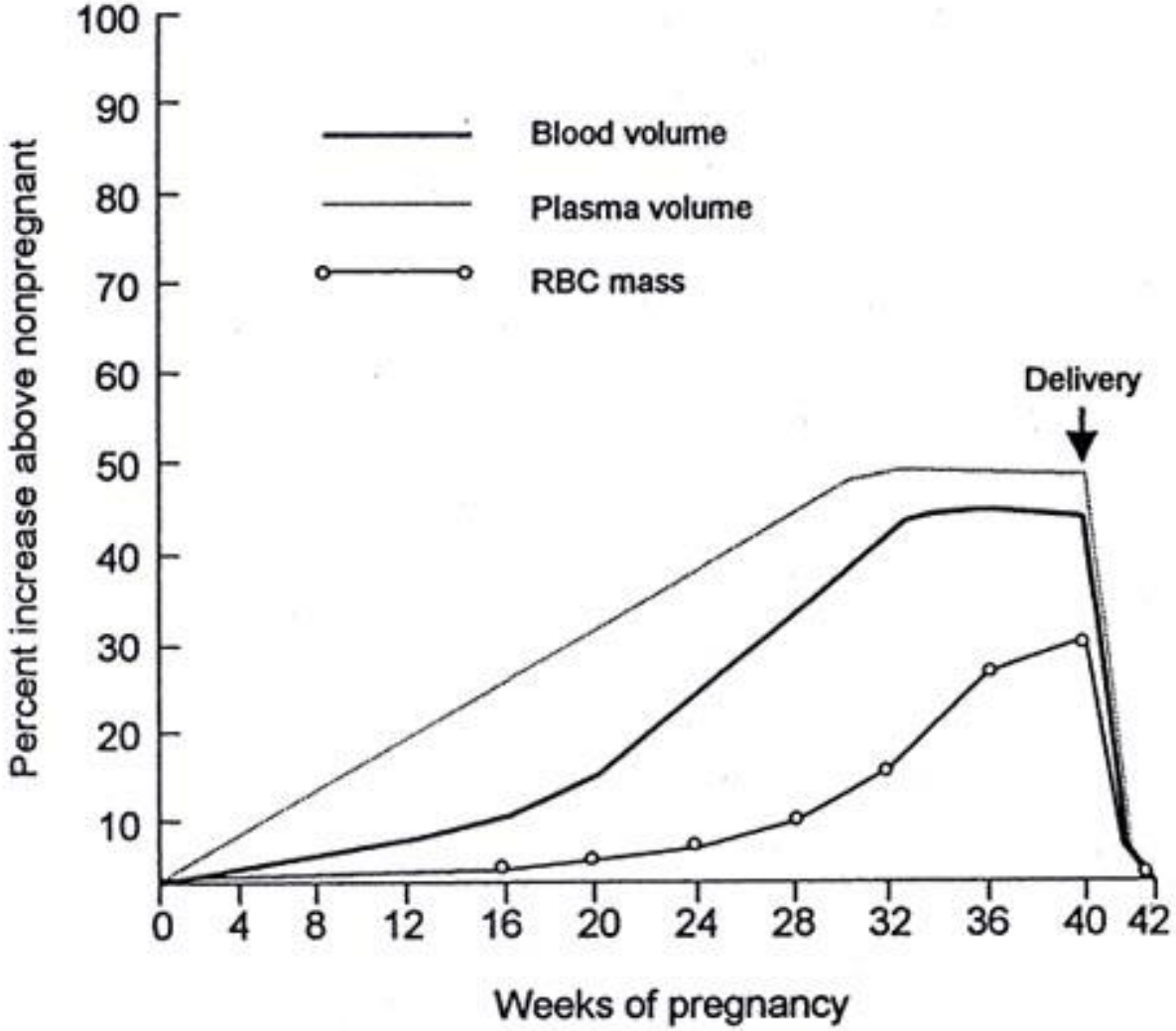


Figure 3–11. Blood volume changes during pregnancy. (From Scott D: Anemia during pregnancy. Obstet Gynecol Ann 1:219, 1972.)

Hematologic

- **Hypercoagulable**
  - Estrogen & Vascular stasis
  - Increased risk for thromboembolic disease
    - Increase in fibrinogen, and most coagulation factors
    - Fall in protein S and sensitivity to APC
    - Fibrinolytic activity decreases
- Fall in platelets and factor XI and XIII
- Increase in WBC

Changes in the Pump

- Cardiac axis displaced cephalad and left
  - PMI lateral & elevated (not just due to baby!)
    - Altered thoracic dimensions
  - Left axis deviation
- Murmurs > 96%
  - Virtually all valves
    - Esp. Aortic and Pulmonary
    - Mammary Souffle
- Rate – increased (80's typical)
- Ventricular distention – 25% increase

More changes in the Pump

- Rhythm
  - Non-specific ST & T changes
  - Increase in dysrhythmias
    - Physiologic hypokalemia
- Anatomy
  - LVH & Pericardial effusion
- Function
  - Increased & markedly fluctuating output

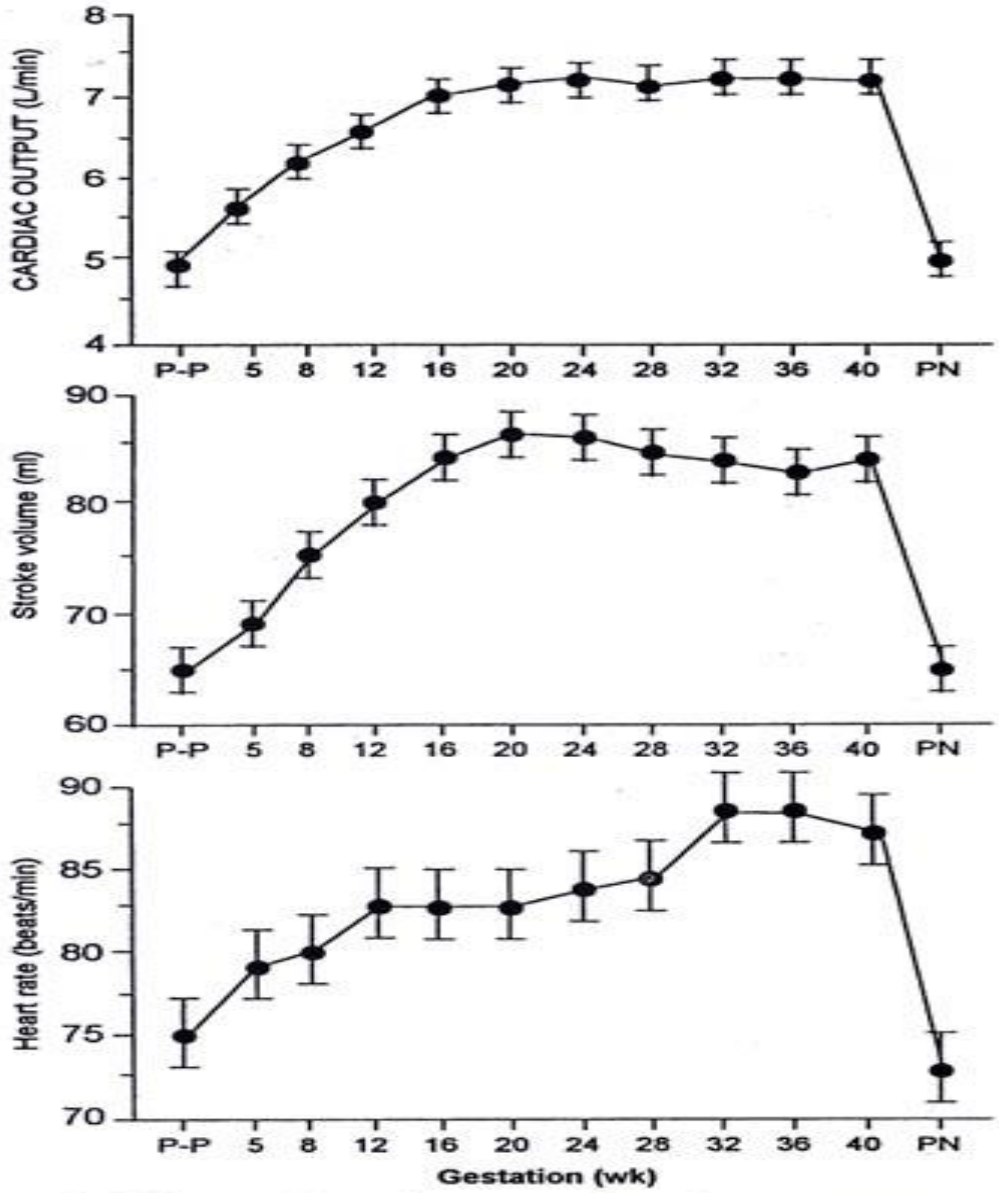
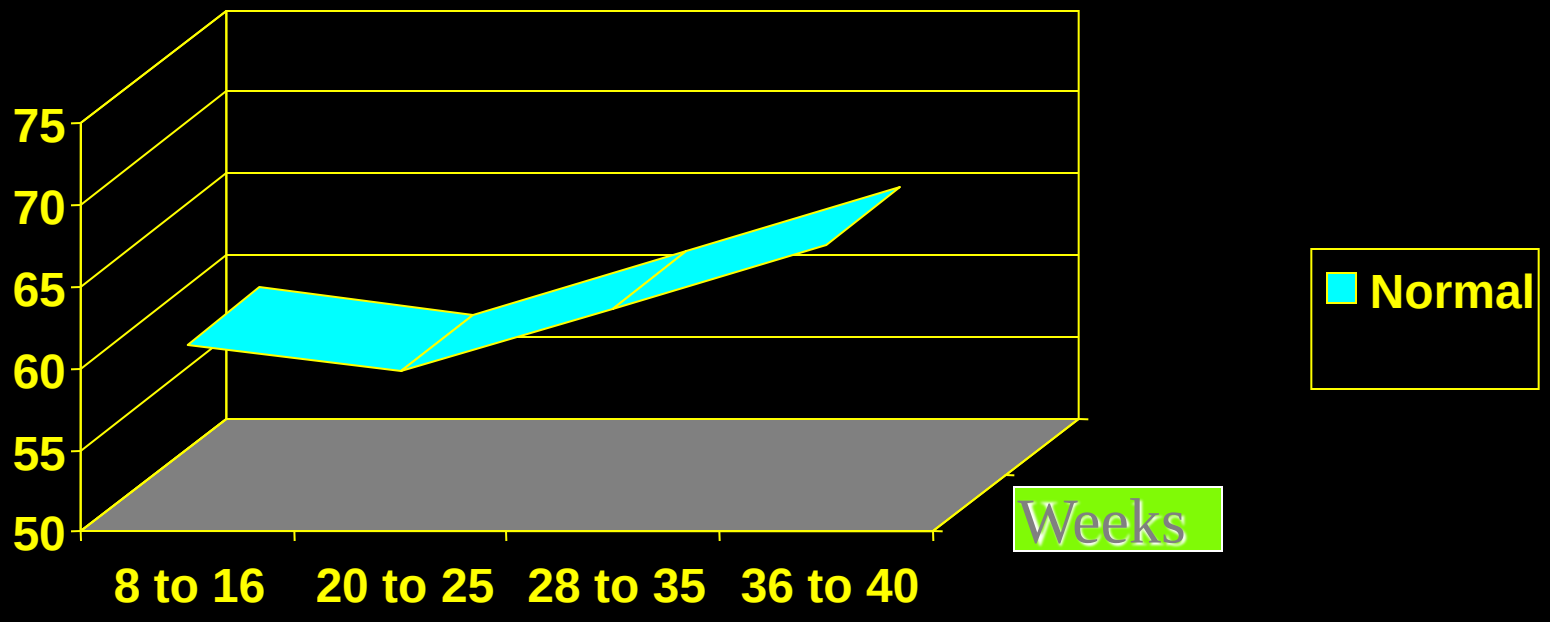


Figure 3–3. Increase in cardiac output from the nonpregnancy state throughout pregnancy. P-P, pre-pregnancy; PN, postnatal. (From Hunter S, Robson S: Adaptation of the maternal heart in pregnancy. Br Heart J 68:540, 1992, with permission.)

Blood Pressure



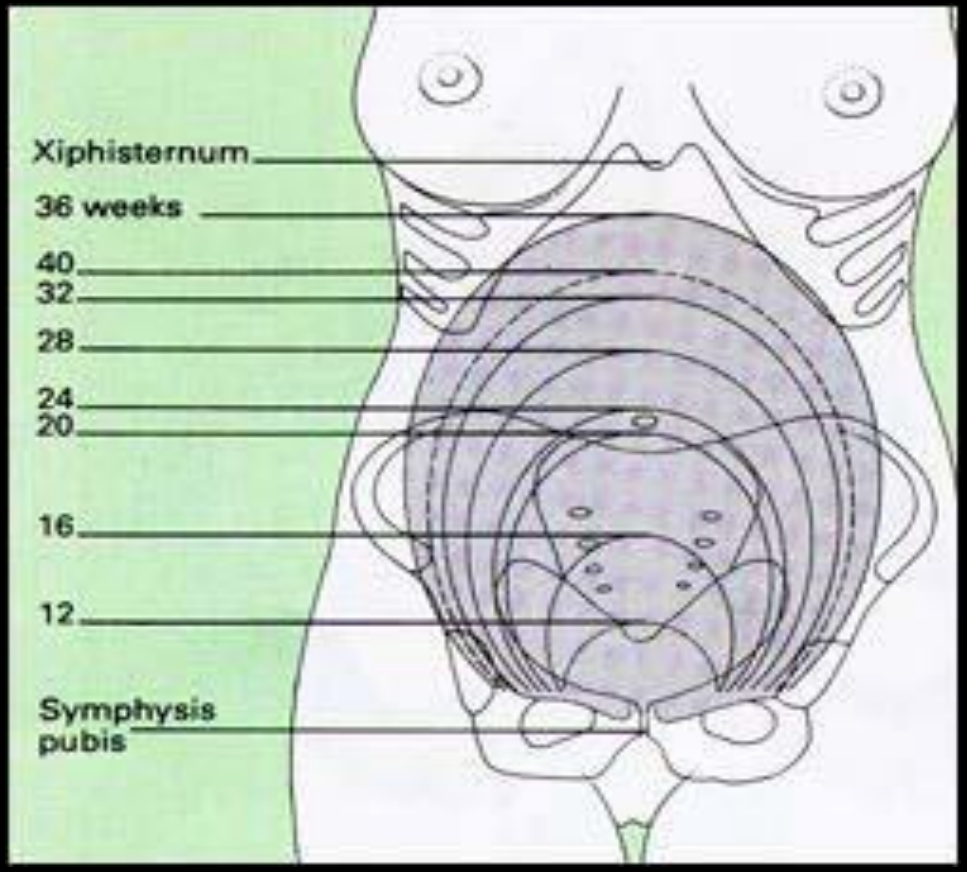
(Benedetto et al, Obstet Gynecol, 1996)

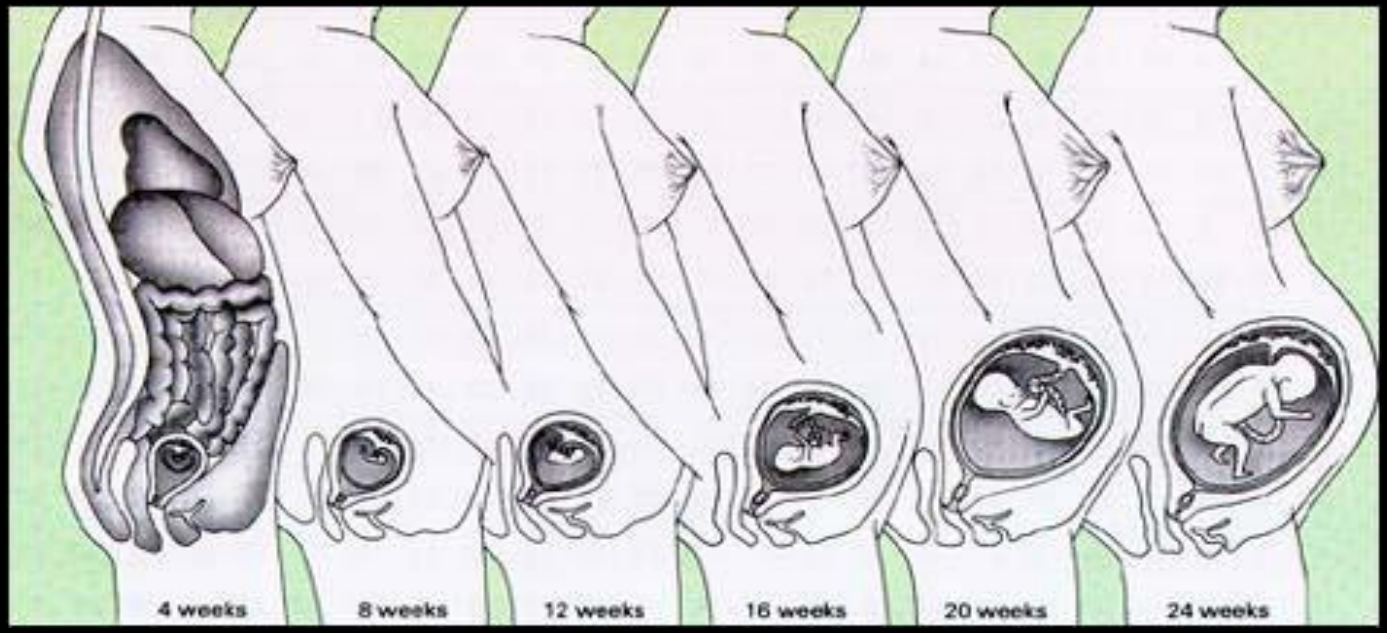
Pregnancy Adaptations

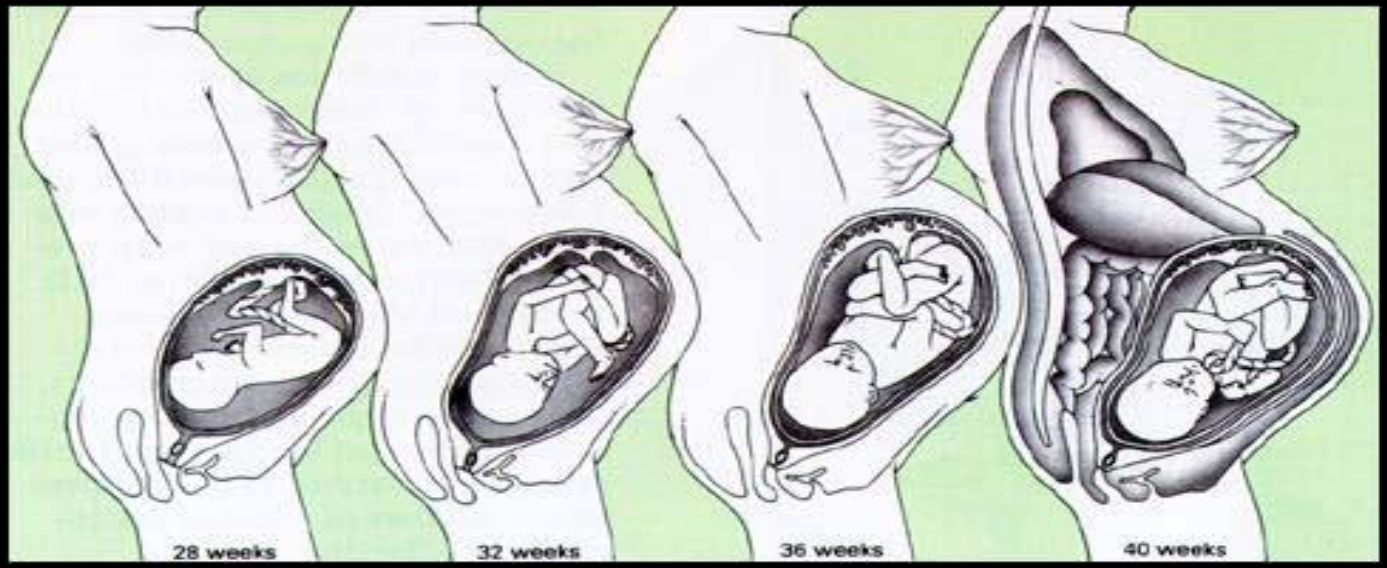
Factor	Preg.	NonPrg	Change
CO	6.2	4.3	+43%
MAP	86	90	-10%
SVR	1210	1530	-21%
PVR	78	119	-34%
HR	83	71	+17%

Anatomical considerations

Uterine Position over Time




4 weeks
8 weeks
12 weeks
16 weeks
20 weeks
24 weeks


28 weeks
32 weeks
36 weeks
40 weeks

Cardiac Output – Positional Effects

- Aorto-caval Compression
  - <23 wks - No change
  - 24-28 wks - Decrease by 8%
  - 29-32 wks - Decrease by 14%
  - 33-term - Decrease by 25%

Labor Changes

- SVR – Increased 10-25% with CTX
- Volume – autotransfusion 300-500cc
- Cardiac output -
  - <3cm Increased 17%
  - 4-7cm Increased 23%
  - >8cm Increased 34%

» Changes over pregnancy baseline CO.

The Fetus and Placenta

- Fetus (aka – “the parasite”)
  - A sensitive survivor
  - A window
- Placenta
  - A veritable hormone factory
  - Receives 20-25% of cardiac output*
    - 750-1000 ml/min
    - Refractory to vasoactive meds
  - Uses as much O_2 as fetus

Signs & Symptoms of Normal Pregnancy that may Mimic Heart Disease

- Signs
  - Peripheral edema
  - JVD
- Symptoms
  - Reduced exercise tolerance
  - Dyspnea
- Auscultation
  - S3 gallop
  - Systolic ejection murmur
- Chest x-ray
  - Change in heart position & size
  - Increased vascular markings
- EKG
  - Nonspecific ST-T wave changes
  - Axis deviation
  - LVH

Changes in the Filter

- Renin – stimulated by progesterone
  - Also made by placenta
  - Angiotensinogen ➡ Angiotensin I ➡ Angiotensin II ➡ Aldosterone ➡ Distal tubule
    - Net absorption of Na^+
    - Excretion of K^+
    - Water retention: **6-8 liters**
- Increased renal blood flow
  - 50-75% increase
  - GFR – 50% increase
  - Decreased Albumin = lower colloid oncotic pressure

Other urinary tract changes

- Ureteral dilation / hydroureter
  - Smooth muscle relaxation
  - Later exacerbation by uterine obstruction
  - Urinary stasis*
- Dilation of pelves and calyces
- Increased kidney size

Lungs and respiration

Respiratory Adaptations

- No change in rate or IRV
- Thorax
  - Tr. Diameter 2cm; circumference 5-7cm
- Increased minute ventilation
- Reduced FRC – 20%
- Increased Tidal Volume – 30-40%
- Compensated respiratory alkalosis
  - pH 7.4+
  - ↑PaO_2; ↓$PaCO_2$ (40 – 30)
  - Drives gradient b/w mom and fetus

Respiratory Changes

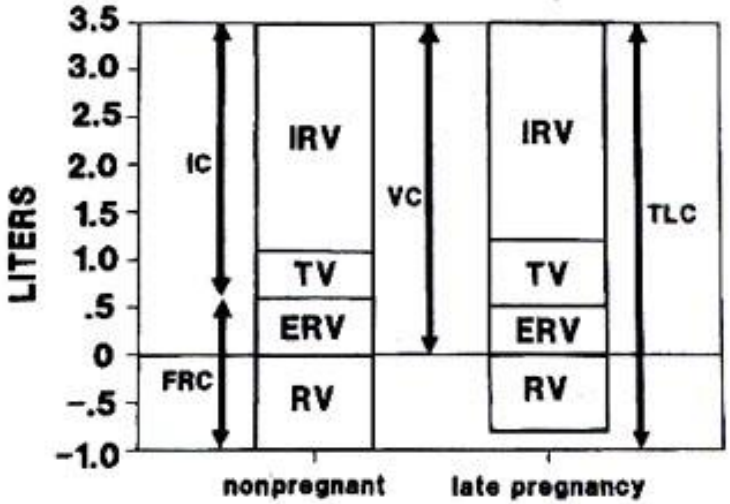


Figure 3–10. Lung volumes in nonpregnant and pregnant women. TLC, total lung capacity; VC, vital capacity; IC, inspiratory capacity; FRC, functional residual capacity; IRV, inspiratory reserve volume; TV, tidal volume; ERV, expiratory reserve volume; RV, residual volume. (From Cruickshank DP, Wigton TR, Hays PM: Maternal physiology in pregnancy. *In* Gabbe SG, Niebyl JR, Simpson JL [eds] Obstetrics: Normal and Problem Pregnancies, 3rd ed. New York, Churchill Livingstone, 1996, p 94, with permission.)

Gastrointestinal

- Slowed GI motility
  - Constipation, early satiety
- Relaxation of LES
  - GERD
- Nausea / vomiting
  - Often proportional to HCG level
- Liver / gallbladder
  - Biliary stasis, cholesterol saturation
    - More stones
  - Coagulation factors
  - Increased binding proteins (thyroid, steroid, vitamin D)

Other “Adaptations”

- “I can’t see my feet!!!”
  - Altered center of gravity
  - Altered gait
  - Greater joint laxity
    - Widening of symphysis pubis
    - Affects other joints
    - Thorax; widened costovertebral angle
  - Fatigue / somnolence

Integumentary Changes

- Spider angiomata and palmar erythema
- Hair growth (abdomen and face)
- Mucosal hyperemia
- Striae gravidarum
- Hyperpigmentation (esp. linea nigra)
  - Rashes and acne relatively common

Other Endocrine

- Pancreas
  - Carbohydrate metabolism -Insulin resistance
    - Human placental lactogen, cortisol
- Thyroid Function
  - Increased TIBG (via liver)
  - Increased total T_4 and T_3
    - free levels unchanged
    - HCG suppresses TSH
- Adrenal function
  - Free plasma cortisol is elevated
    - CRH from placenta stimulates ACTH

Other Endocrine

- Maternal total plasma calcium concentration falls, because albumin concentration falls

Immunology

- Must adapt to accept ‘allograft’
- Immune response altered, but not deficient
- Modulates away from cell-mediated cytotoxic effects
  - Progesterone effect
  - NK cells decrease by 30%
  - Enhanced humoral / innate immunity
    - Immunoglobulins still active
    - IgG crosses placenta
  - More susceptible to CMV, HSV, Varicella, Malaria
  - **Decrease** in symptoms of some autoimmune disorders

Pregnancy – not a disease

- Profound changes in physiology and anatomy
- Affects most organ systems
- Can dramatically impact disease states, susceptibility, and treatment
- Almost all will encounter and treat pregnant women
  - Even if you don't know it
- Under-appreciation of changes will lead to suboptimal treatment or outright mistakes