

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”)



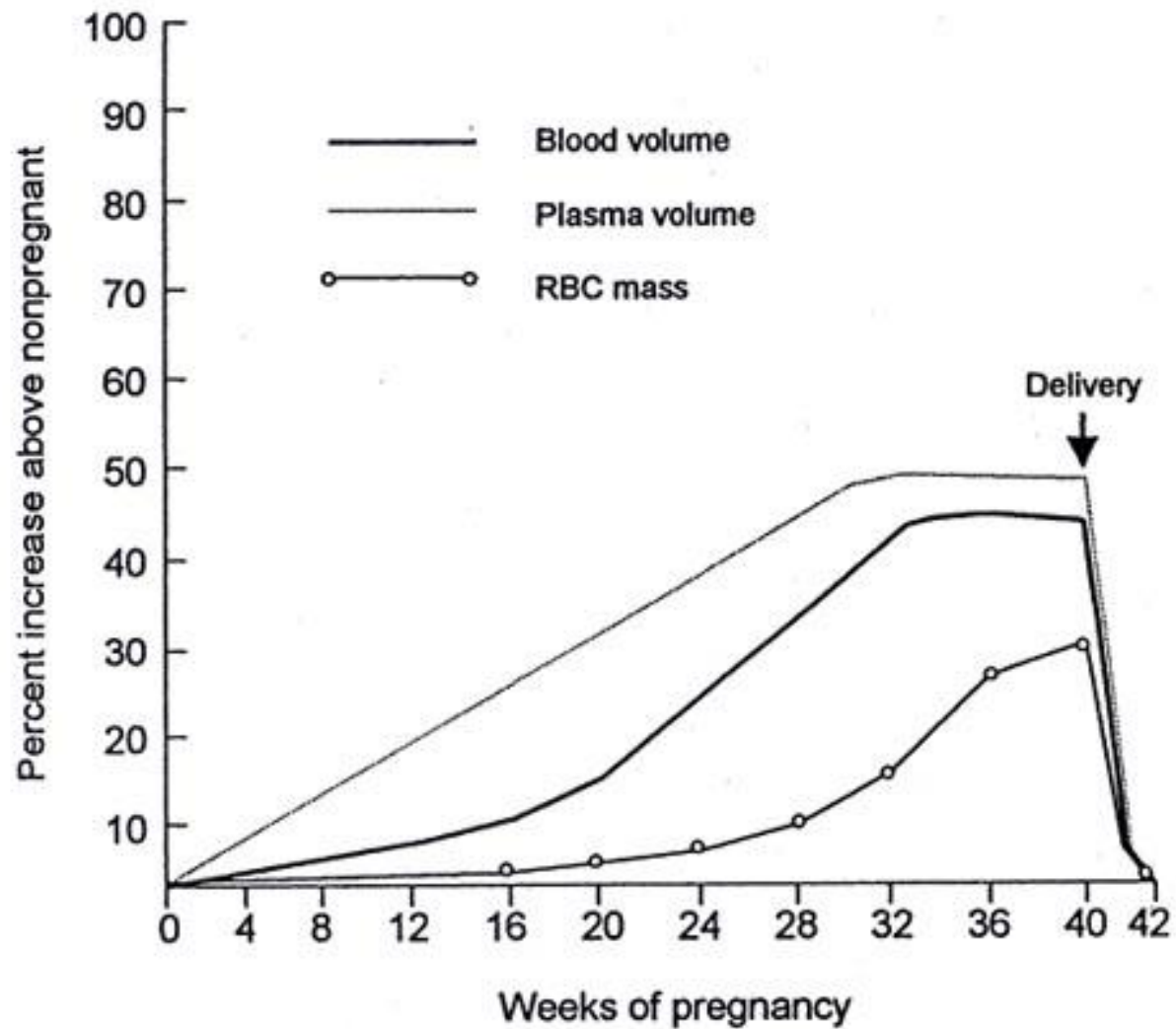


Figure 3-11. Blood volume changes during pregnancy. (From Scott D: Anemia during pregnancy. *Obstet Gynecol Ann* 1:219, 1972.)



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



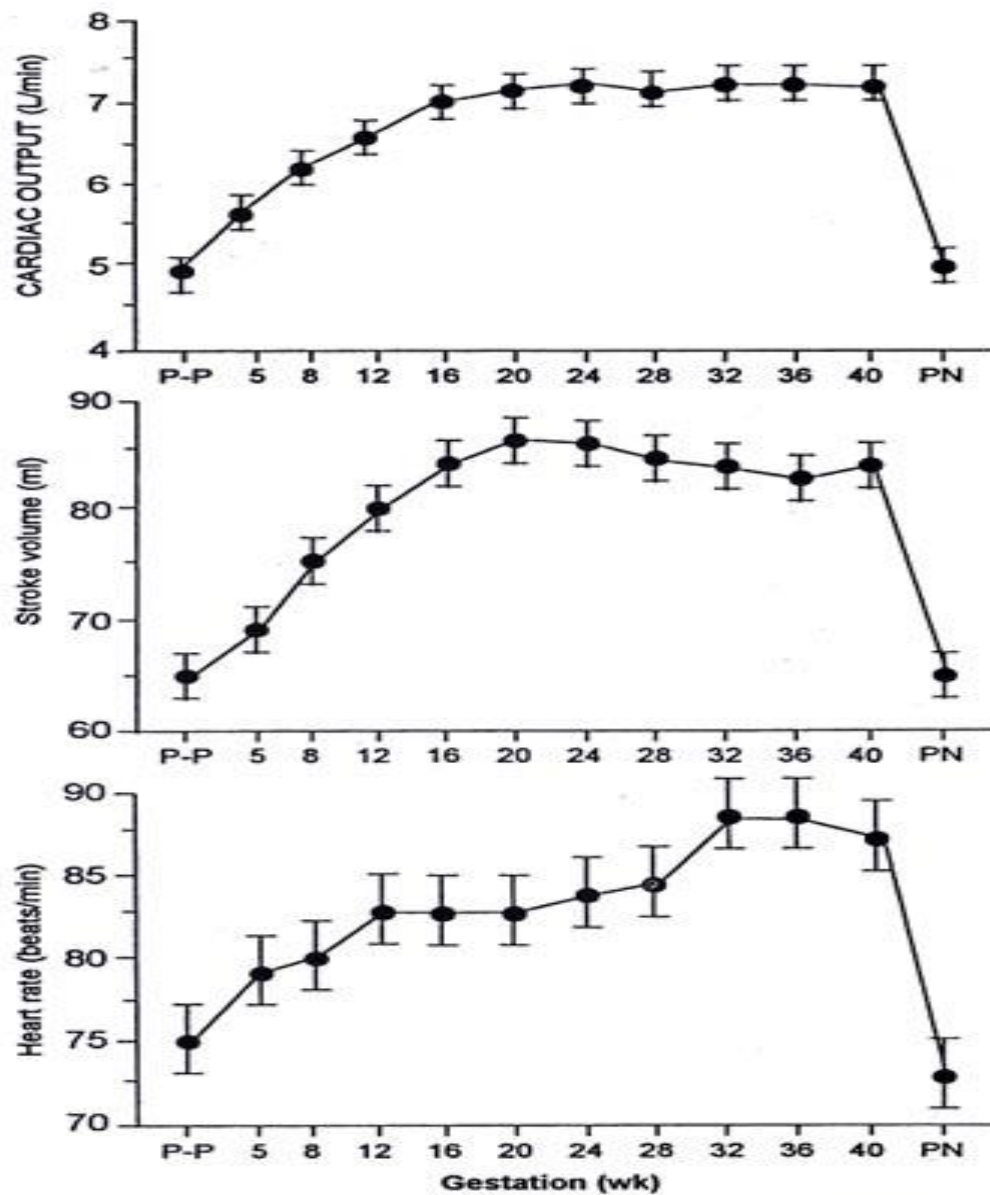
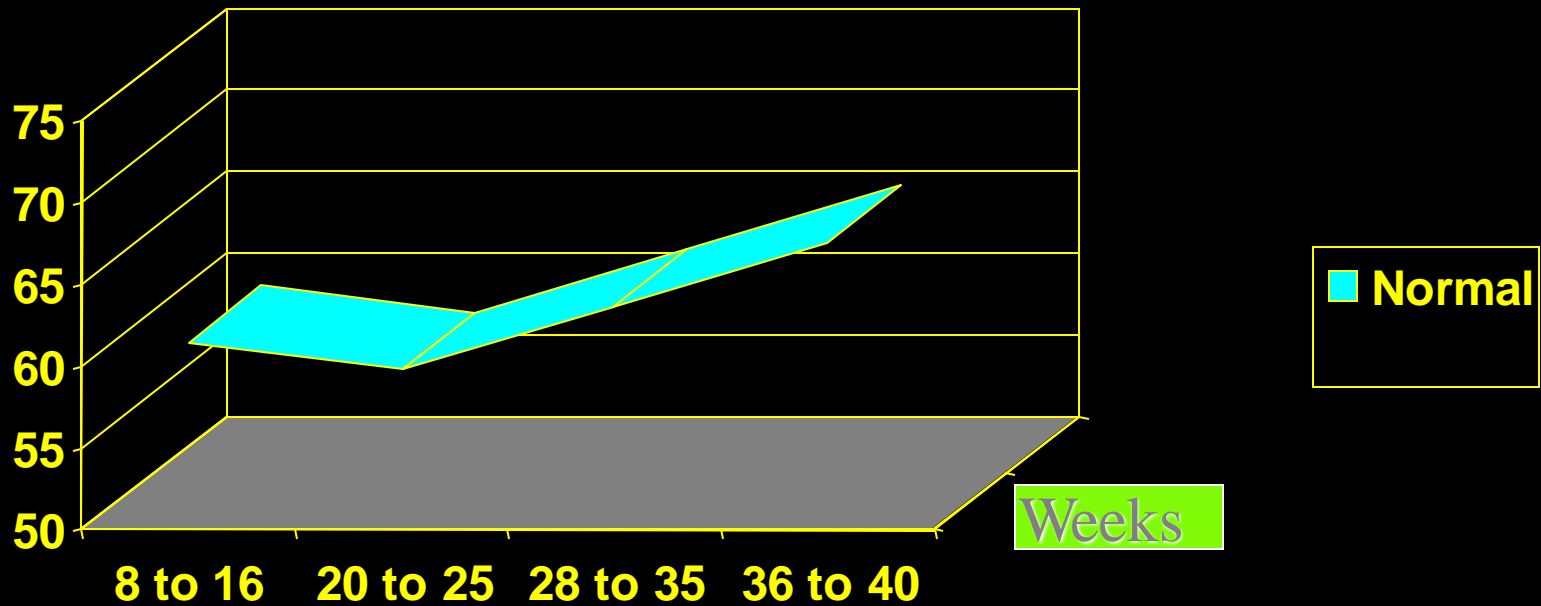


Figure 3-3. Increase in cardiac output from the nonpregnancy state throughout pregnancy. P-P, pre-pregnancy; PN, postnatal. (From Hunter S, Robson S: Adaptation of the maternal heart in pregnancy. *Br Heart J* 68:540, 1992, with permission.)



Blood Pressure



(Benedetto et al, Obstet Gynecol, 1996)



Pregnancy Adaptations

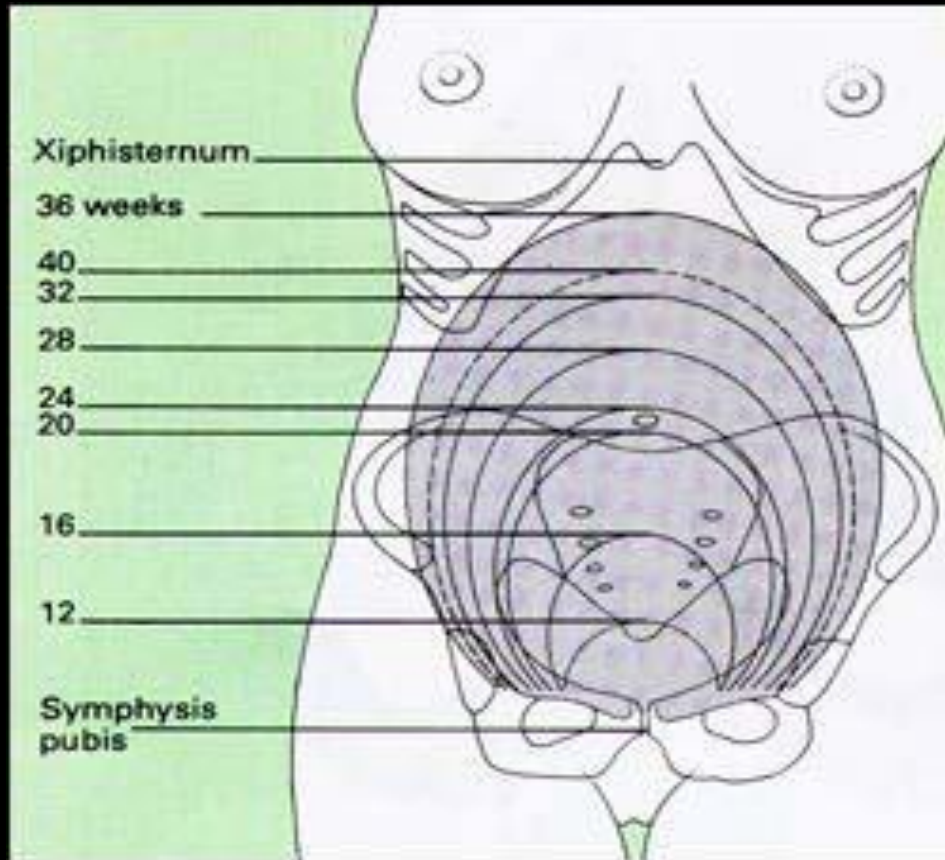
Factor	Preg.	NonPrg	Change
<i>CO</i>	6.2	4.3	+43%
<i>MAP</i>	86	90	-10%
<i>SVR</i>	1210	1530	-21%
<i>PVR</i>	78	119	-34%
<i>HR</i>	83	71	+17%

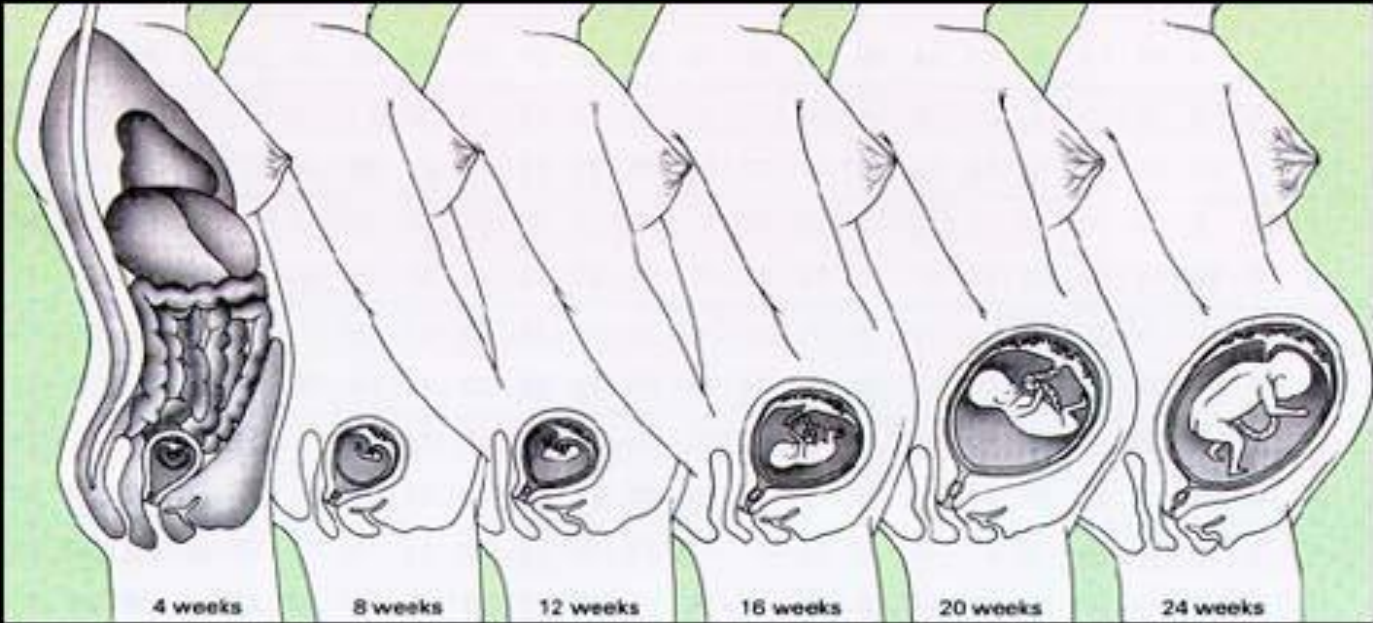


Anatomical considerations



Uterine Position over Time





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 O₂ 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+
 - \uparrow PaO₂; \downarrow PaCO₂ (40 – 30)
 - Drives gradient b/w mom and fetus



Respiratory Changes

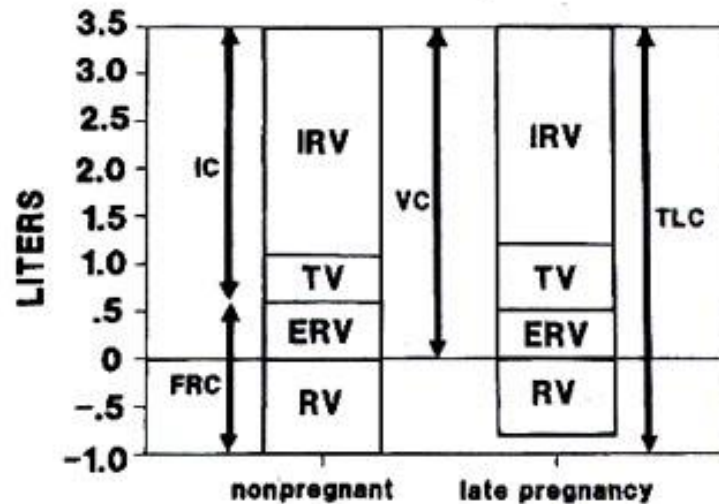


Figure 3-10. Lung volumes in nonpregnant and pregnant women. TLC, total lung capacity; VC, vital capacity; IC, inspiratory capacity; FRC, functional residual capacity; IRV, inspiratory reserve volume; TV, tidal volume; ERV, expiratory reserve volume; RV, residual volume. (From Cruickshank DP, Wigton 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 angiomas 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 T₄ and T₃
 - 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

