

Pregnancy: hemodynamic effects

Definition

Plasma volume increases 45% at term, RBC volume increases 20%, thus while pregnant patients have increased RBC mass, they appear anemic. Normal hemoglobin is 12 g/dL. During labor, contractions squeeze blood into the systemic circulation, and after delivery, uterine involution autotransfuses 500 cc/blood. Note that clotting factors (I, VII, VIII, IX, X, XII) are elevated, protein S (anticoagulant) is decreased, and there is acquired resistance to protein C. Pregnancy is thus a hypercoagulable state. Also note that both platelet generation and destruction increase, with variable effects. Importantly, 7.6% of term parturients have platelets < 150,000, and 1% have < 100,000 platelets at term.

Both stroke volume and heart rate increase, the end result being a 40-50% increase in cardiac output by the third trimester (maximal at 24 weeks) – immediately after delivery it can be as high as 80% above normal (150% above pre-pregnancy levels). Increased CO may be detrimental to women with valvular lesions (ex. stenotic lesions). Pregnant women **may also develop systolic regurgitation murmurs (usually mitral or tricuspid in origin)**.

Note that the **heart is displaced cephalad and laterally, and the EKG changes of pregnancy** include 1) sinus tachycardia 2) other dysrhythmias 3) ST depression 4) T wave flattening 5) LVH and 6) LAD

Decreases in SVR as result in reduced SBP (avg 8%, as much as 15%) and DBP (avg 20%), likely due to changes in estradiol, progesterone, nitric oxide, and prostacyclin. Increases in venous capacitance and myocardial remodeling attenuate the increased blood volume (i.e. CVP remains constant)

Aortocaval compression can occur in as many as 20% of pregnant women, and can lead to several problems. First, it can lead to maternal hypotension and subsequent fetal acidosis (usually if SBP is 90 – 100 mm Hg for 10 or more minutes), and second, it can dilate the epidural veins (*Batson's plexus*), leading to intravascular injection during epidural anesthesia. Treat with lateral positioning or a right-sided hip wedge

Maternal Hemodynamic Effects

- Hematologic: plasma volume increases 45% at term, RBC volume increases 20%
- Cardiac Output: stroke volume and heart rate increase
- Vascular resistance: decreases in SVR as result in reduced SBP
- Venous Return: **aortocaval compression** can occur in as many as 20% of pregnant women

Note that approximate **blood loss** is **300-500 cc** for a vaginal delivery and **800-1000 cc** for a **Cesarean section**.

Pregnancy: Lung volumes

Definition

Decreased functional residual capacity is seen, typically falling from 1.7 to 1.35 litres, due to the compression of the diaphragm by the uterus. The compression also causes a decreased total lung capacity (TLC) by 5% and decreased expiratory reserve volume. Tidal volume increases with 30-40%, from 0.45 to 0.65 litres,[citation needed] and minute ventilation by 30-40% giving an increase in pulmonary ventilation. This is necessary to meet the increased oxygen requirement of the body, which reaches 50 mL/min, 20 mL of which goes to reproductive tissues. Overall, the net change in maximum breathing capacity is zero.

Pregnancy – Hemostasis

Definition

Hemostasis undergoes major changes in normal pregnancy. These changes contribute in maintaining placental function and preventing excessive bleeding. Most changes in coagulation create a state of hypercoagulability

that serves to protect the mother from hemorrhage during delivery. Unfortunately, these changes can also predispose women to thromboembolism. It is important to note that complications with pregnancy such as pre-eclampsia, hemorrhage, infection, etc. can have multiple deleterious coagulopathies which are not specifically discussed here.

Platelets: Thrombocytopenia is the most common hemostatic abnormality observed in healthy women. Part of this is due to hemodilutional effects but increases in mean platelet volume suggests that there exists compensated platelet destruction as well.

Coagulation System: In normal pregnancy you see significant increases in factor VII, VIII, IX, X, XII, vWF and fibrinogen but relatively no changes to factors II and V. Protein C and anti-thrombin appear to be unaffected, while Protein S appears to decrease but it is unclear if this drop plays into the hypercoagulability of pregnancy

Fibrinolytic activity is reduced during pregnancy and remains low during labor and delivery. Fibrinolysis is reduced in pregnancy due to decreases in t-PA activity, which remains low until 1 hour postpartum and then returns to normal. Three weeks after delivery blood coagulation and fibrinolysis appears to generally return to normal levels.

Pregnancy: GE reflux mechanism

Definition

According to Miller, “**Progesterone relaxes smooth muscle**; consequently, it impairs esophageal and intestinal motility during pregnancy. **Whether gastric emptying is delayed during pregnancy is controversial.** Wong and coworkers suggest that the ingestion of 300 mL of water may actually enhance gastric emptying in healthy, term, nonobese, nonlaboring parturients. However, the risk of pulmonary aspiration of gastric contents remains real in parturients”

That said, **deaths from aspiration occur as commonly as deaths from cannot intubate / cannot ventilate situations.** Note that Hawkins’ analysis of maternal deaths found 33 deaths from aspiration during general

anesthesia, as compared to 37 deaths from either “induction/intubation problems” or “inadequate ventilation” [Hawkins JL et al. *Anesthesiology* 86: 277, 1997]. Note that these data are pre-LMA in the United States (1990 was the last year included in Hawkins’ analysis, the LMA was not available until 1991). Stoelting recommends treating all pregnant women as though they had a full stomach (RSI?), using a cuffed endotracheal tube, and administering non-particulate antacids prior to induction.

GI Effects of Pregnancy

- Relaxation of smooth muscle
- Impaired esophageal and intestinal motility
- Effect on gastric emptying is controversial