- Without iron supplementation, the optimal increase in maternal erythrocyte volume will not occur, and the Hgb and Hct will fall as the plasma volume increases.
- At the same time, fetal red cell production is not impaired because the placenta transfers iron even if the mother has severe IDA.

# Puerperium

- Not all the maternal iron added in the form of Hgb is lost with normal delivery
- During vaginal delivery and the first postpartum days, only approximately half of the added erythrocytes are lost from most women.
  - These normal losses are from the placental implantation site,
- episiotomy or lacerations, and lochia
  On average, the mother loses 500 to 600 ml of predelivery whole blood during vaginal delivery of a single fetus. With twins or a cesarean delivery, the loss is approximately 1000 ml.

#### Immunological functions

- Pregnancy is both a pro-inflammatory and anti-inflammatory condition, depending on the stage of gestation.
  - Early pregnancy is inflammatory.
    - During implantation and placentation, the blastocyst must break through the uterine cavity epithelial lining to invade endometrial tissue. Trophoblast must then replace the endothelium and vascular smooth muscle of the maternal blood vessels to secure an adequate blood supply for the placenta.
  - Midpregnancy is anti-inflammatory
    - In this period of rapid fetal growth and development, the predominant feature is induction of an anti-inflammatory state.
  - Parturition is inflammatory
    - Influx of immune cells into the myometrium to promote recrudescence of an inflammatory process
- An important anti-inflammatory component of pregnancy involves suppression of Th1 and Tc1 cells, which decreases secretion of IL-2, IFN-Y, and TNF-B
- Leukocytes:
  - In the second trimester and throughout pregnancy, some PMN chemotaxis and adherence functions are depressed. This might be related to relaxinmediated impairment of neutrophil activation.
  - Leukocyte count ranges during pregnancy are higher than nonpregnant values. This might be due to reappearance of leukocytes previously shunted out of an active circulation.
  - Distribution of cell types is altered significantly
    - During the third trimester there is the rease in granulocytes and CD8 T lymphocytes, along with the promising reduction in the percent at of CP1-1 lymphocytes, and whonocytes
       Circulating reaction to sender the percent at the percent at
  - Circulating takon tes undergo phenotypic changes it audin, upreculation of certain adhesion molecules.
- Inflammatory markers
  - Tests used to diagnose inflammation cannot be used reliably during pregnancy, as there will be false elevations

## Coagulation and fibrinolysis

- During normal pregnancy, both coagulation and fibrinolysis are augmented but remain balanced to maintain hemostasis. They are even more enhanced in multifetal gestation.
  - Increased concentrations of all clotting factors except factors XI and XIII. Clotting time, however, does not differ significantly.
  - Increased fibrinogen concentrations, as evidenced by increased ESR
  - Fibrinolysis might be impaired, but may be counter-regulated to ensure hemostatic balance in normal pregnancy
- Platelets
  - Average platelet concentration decreases slightly during pregnancy due to hemidilutional effects, increased platelet consumption and hypersplenism

#### Spleen

- Splenic enlargement possibly due to increased blood volume and/or the hemodynamic changes or pregnancy
- Sonographically, the spleen remains homogeneously echogenic throughout gestation.

## Cardiovascular system

# Heart

- As the diaphragm becomes progressively elevated, the heart is displaced to the left and upward, and is rotated on its long axis. The apex thus moves laterally from its usual position and produces a larger cardiac silhouette on CXR.
- No characteristic ECG readings other than slight left-axis deviation due to altered heart position

- Many of the normal cardiac sounds are modified
- Structurally, the increasing plasma volume seen during normal pregnancy is reflected by enlarging cardiac end-systolic and end-diastolic dimensions No associated changes in septal thickness or in ejection fraction
  - This is because the dimensional changes are accentuated by
    - This is because the dimensional changes are accentuated by substantive ventricular remodeling, which is characterized by eccentric left-ventricular mass expansion

#### Cardiac output

- During normal pregnancy, mean arterial pressure and vascular resistance decrease, while blood volume and basal metabolic rate increase. As a result, cardiac output at rest, when measured in the lateral recumbent position, increases significantly in early pregnancy. It continues to increase and remains elevated during the remainder of pregnancy.
- During late pregnancy, in a supine woman, the large uterus consistently compresses venous return from the lower body and may compress the aorta. Thus, cardiac filling may be reduced and cardiac output diminished.
- Upon standing, cardiac output falls to the same degree as in the nonpregnant woman.
- During the first stage of labor, cardiac output increases moderately. During the second stage, with vigorous expulsive efforts, it is appreciably greater.
- The pregnancy-induced increase is lost after delivery, at times dependent on blood loss.

## Hemodynamic function in late pregnancy

Although cardiac output is increased, left ventricular function as measured by stroke work index remains similar to the nonpregnant normal range.

#### Circulation and blood pressure

- Changes in posture affect arterial blood pressure Brachial artery pressure when sitting in lover can when in the lateral
- recumbent supine position. Arterial pressure decreases to a narry 24 to 26 weeks and rises thereafter. Diastolic pressure elecases more than systolic pressure.

Diastolic pressure to care more than systolic pressure. Antonut to ye to spressure remains unchanged during pregnancy. In the supine to turn, ...wever, femoral venous pressure rises steadily.

Venous blood flow in the legs is retarded during pregnancy except when the late it return bent position is assumed. This contributes to development of varice title and hemorrhoids, as well as dependent edema. They also predispose to DVT.

Supine hypotension due to compression of the great vessels by the uterus when supine. This also leads to lower uterine blood flow, potentially affecting fetal heart rate patterns.

## Renin, angiotensin II, and plasma volume

- Intimately involved in blood pressure control via sodium and water balance
  - All components of this system are increased in normal pregnancy.
  - > Renin produced by both the maternal kidney and the placenta
  - Increased angiotensionogen production by maternal and fetal liver due to increased estrogen production (important in first trimester blood pressure maintenance)
- Development of refractory vascular reactivity to angiotensin II due to progesterone

## Cardiac natriuretic peptides

- Secreted in response to chamber-wall stretching
- Regulate blood volume by promoting natriuresis, dieresis and vascular smooth muscle relaxation
- ANP and BNP levels maintained at nonpregnant range despite increased plasma volume
  - ANP-induced physiological adaptations participate in extracellular fluid volume expansion and in the increased plasma aldosterone concentration characteristic of normal pregnancy

# Prostaglandins

- Increased prostaglandin production during pregnancy has a central role in control of vascular tone, blood pressure and sodium balance
  - Renal medullary PGE2 synthesis increased in late pregnancy; probably natriurteic
  - PGI2, the principal prostaglandin of endothelium, also increased in late pregnancy; implicated in the development of angiotensin resistance in pregnancy.

# Endothelin

Endothelin-1 is a potent vasoconstrictor produced in endothelial and vascular smooth muscle cells and regulates vasomotor tone. Vascular sensitivity to it is not