

FETAL AND NEONATAL PHYSIOLOGY

EBAA M ALZAYADNEH, PHD
ASSISTANT PROFESSOR,
PHYSIOLOGY AND BIOCHEMISTRY DEPARTMENT
THE UNIVERSITY OF JORDAN



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DEVELOPMENT OF THE ORGAN SYSTEMS OF FETUS

Within 1 month after fertilization of the ovum, the gross characteristics of all the different organs of the fetus have already begun to develop.

during the next 2 to 3 months, most of the details of the different organs are established.

Beyond month 4, the organs of the fetus are grossly the same as those of the neonate. However, cellular development in each organ is incomplete.

In the full remaining 5 months of pregnancy are needed to complete development.



DEVELOPMENT OF THE ORGAN SYSTEMS

Circulatory System



THE HUMAN HEART BEGINS BEATING DURING
THE FOURTH WEEK OF GESTATION AT A RATE
OF ABOUT 65 BEATS/MIN.

| 40 BEATS/MIN IMMEDIATELY BEFORE BIRTH.



FETAL CIRCULATION

- Low flow to lungs and liver is only partially functional.
- High flow to placenta.
- The blood from the placenta(well oxygenated) through the umbilical vein →the ductus venosus bypassing the liver the inferior vena cava →right atrium →the foramen ovale →left atrium→ left ventricle mainly into the arteries of the head and forelimbs.
- The blood (deoxygenated) entering the right atrium from the superior vena cava →right ventricle →the pulmonary artery → descending aorta through ductus arteriosus→ the two umbilical arteries → the placenta, oxygenation

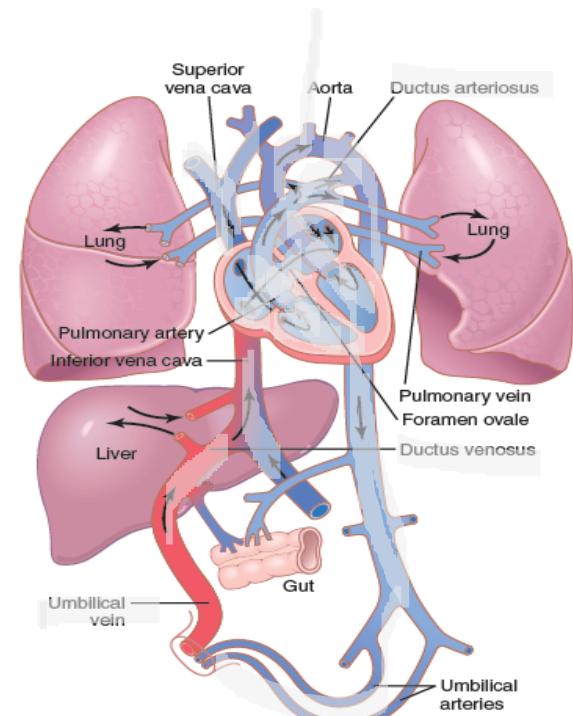


Figure 84-4. Organization of the fetal circulation.



Development of the Organ Systems



- FORMATION OF BLOOD CELLS.
- NUCLEATED RED BLOOD CELLS BEGIN TO BE FORMED IN THE YOLK SAC AND MESOTHELIAL LAYERS OF THE PLACENTA AT ABOUT THE THIRD WEEK OF FETAL DEVELOPMENT
- at 4 to 5 weeks by formation of non-nucleated red blood cells by the fetal mesenchyme
- at 6 weeks, the liver begins to form blood cells,
- third month-----the spleen and other lymphoid tissues of the body
- third month on--- the bone marrow becomes the principal source of the red blood cells , white blood cells production.





RESPIRATORY SYSTEM

Respiration cannot occur during fetal life, of course

- attempted respiratory movements do take place beginning at the end of the first trimester of pregnancy.

Attempted respiratory movements caused by:

- Tactile stimuli
- fetal asphyxia

In the later months of fetal life(3-4 M), respiration is inhibited to prevent filling of the lungs with fluid and debris from the meconium excreted by the fetus's gastrointestinal tract into the amniotic fluid. Lungs remain deflated till birth(unknown)

Alveoli secretes clear fluid instead





NERVOUS SYSTEM:

- reflexes of the fetus that involve the spinal cord and even the brain stem are present by the third to fourth months of pregnancy.
- nervous system functions that involve the cerebral cortex are still only in the early stages of development even at birth. Ex. Myelination of main tracts not before 1 year age



GASTROINTESTINAL TRACT:



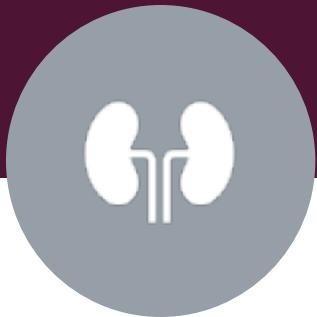
Small quantities of meconium are continually formed in the gastrointestinal tract and excreted from the anus into the amniotic fluid during the last 2 to 3 months.

Meconium is composed partly of residues from swallowed amniotic fluid and excreted from the anus into the amniotic fluid.

Composed of amniotic fluids, mucus, epithelial cells, excretory products from the gastrointestinal mucosa and glands



KIDNEYS:



- The fetal kidneys begin to excrete urine in second trimester pregnancy, and fetal urine accounts for about 70 to 80 per cent of the amniotic fluid.
- Abnormal kidney development or function in the fetus
→(oligohydramnios)and fetal death.
- Renal control systems for regulating fetal extracellular fluid volume and electrolyte balances, and especially acid-base balance, are almost nonexistent until late fetal life and few m after birth



FETAL METABOLISM:

THE FETUS USES MAINLY GLUCOSE FOR:

1-ENERGY, AND IT HAS A HIGH CAPABILITY TO STORE FAT AND PROTEIN.

2-FAT BEING SYNTHESIZED FROM GLUCOSE RATHER THAN BEING ABSORBED DIRECTLY FROM THE MOTHER'S BLOOD.



METABOLISM OF CALCIUM AND PHOSPHATE AND IRON



Calcium and Phosphate:

- 22.5 gm calcium and 13.5 grams of phosphorus are accumulated in the average fetus during gestation.
- About one half of these accumulate during the last 4 weeks of gestation.
- Total amounts of calcium and phosphate needed by the fetus during gestation represent only about 2 % in mom stores in bone

Iron:

About one third of the iron in a fully developed fetus is normally stored in the liver.



METABOLISM

Utilization and Storage of Vitamins

- The B vitamins, especially vitamin B12 and folic acid, are necessary for formation of red blood cells and nervous tissue
- Vitamin C is necessary for appropriate formation of intercellular substances(bone matrix and CT fibers).
- Vitamin D is needed for normal bone growth in the fetus.
- Vitamin K is used by the fetal liver for formation of Factor VII, prothrombin, and several other blood coagulation factors.
(imp as it is not produced by the baby until after week or so, trauma during labor)



EXTRAUTERINE LIFE

Adjustments of the Infant to
Extrauterine Life:

Onset of Breathing:

Starts within first minute resulting from

(1) a slightly asphyxiated state incident
to the birth process, but also from

(2) sensory impulses that
originate in the suddenly cooled skin.

(3) If breathing did not start first minute, baby gets more
hypoxic

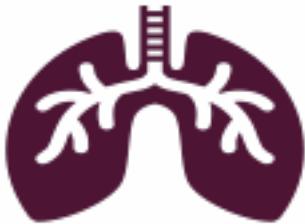
and hypercapnic, stimulating respiratory center and usually
causes breathing within an additional minute after birth.



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EXTRAUTERINE LIFE- HYPOXIA



#In an adult, failure to breathe for only 4 minutes often causes death

#In neonate it can be as long as 10 minutes of failure to breathe after birth.

#Permanent and very serious brain impairment often ensues if breathing is delayed more than 8 to 10 minutes.(thalamus and brain stem)

Hypoxia frequently occurs during delivery due to

(1) compression of the umbilical cord;

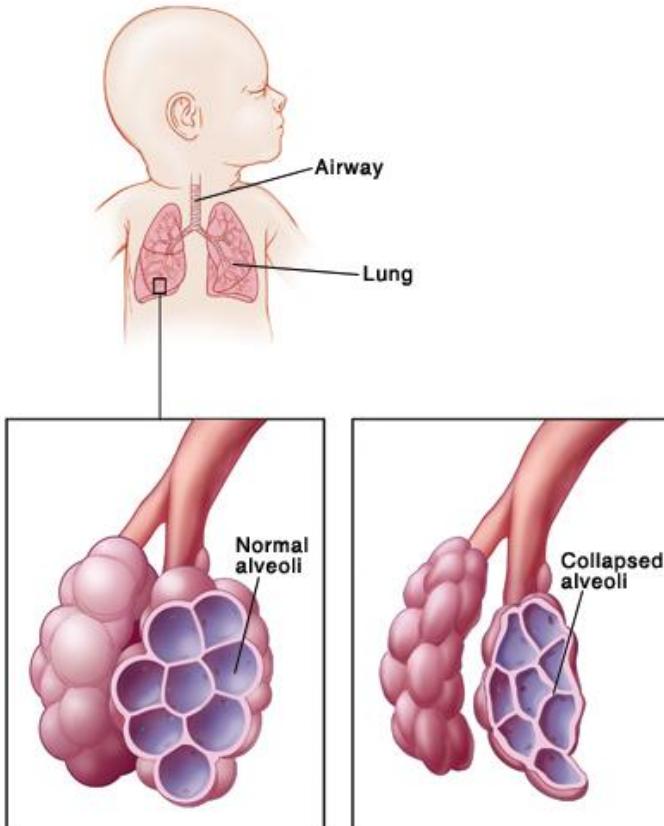
(2) premature separation of the placenta

(3) excessive contraction of the uterus, which can cut off the mother's blood flow to the placenta

(4) excessive anesthesia of the mother, which depresses oxygenation even of her blood

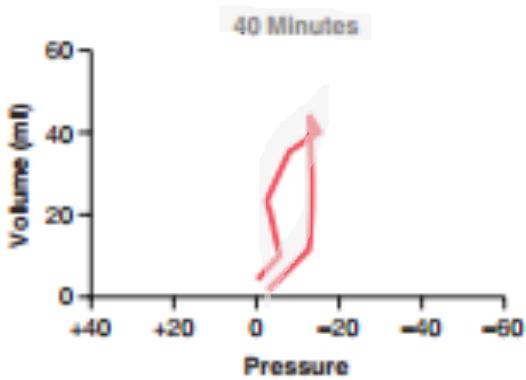
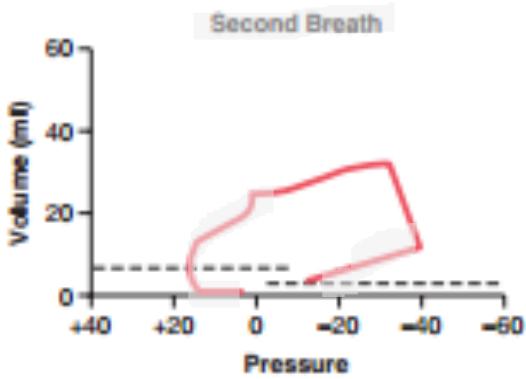
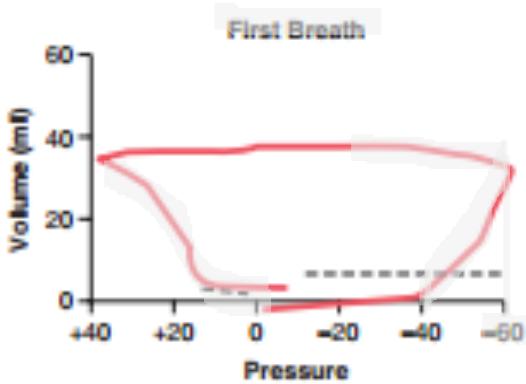


EXPANSION OF THE LUNGS AT BIRTH:



- More than 25 mm Hg of negative inspiratory pressure in the lungs is usually required to oppose the effects of this surface tension and to open the alveoli for the first time
- Respiratory distress syndrome :failure of the respiratory epithelium to secrete adequate surfactant-that decreases the surface tension of the alveolar fluid-therefore allowing the alveoli to open easily during inspiration.





EXTRAUTERINE LIFE- CARDIOVASCULAR

PRIMARY CHANGES IN PULMONARY AND SYSTEMIC VASCULAR RESISTANCES AT BIRTH :



1. LOSS OF THE TREMENDOUS BLOOD FLOW THROUGH THE PLACENTA, DOUBLES THE SYSTEMIC VASCULAR RESISTANCE AT BIRTH.

THIS INCREASES THE AORTIC PRESSURE AS WELL AS THE PRESSURES IN THE LEFT VENTRICLE AND LEFT ATRIUM.



2. THE PULMONARY VASCULAR RESISTANCE GREATLY DECREASES AS A RESULT OF EXPANSION OF THE LUNGS.

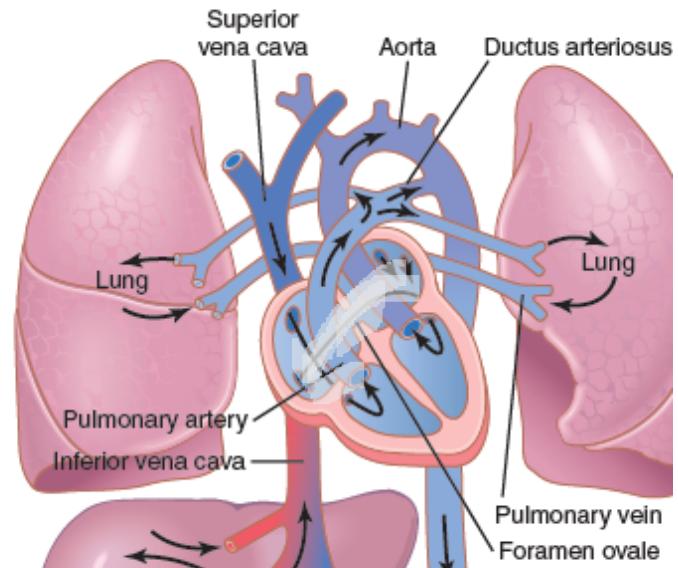
PULMONARY ARTERIES, RT ATRIUM AND RT VENTRICLE PRESSURE DECREASE



EXTRAUTERINE LIFE: CV

Closure of the Foramen Ovale

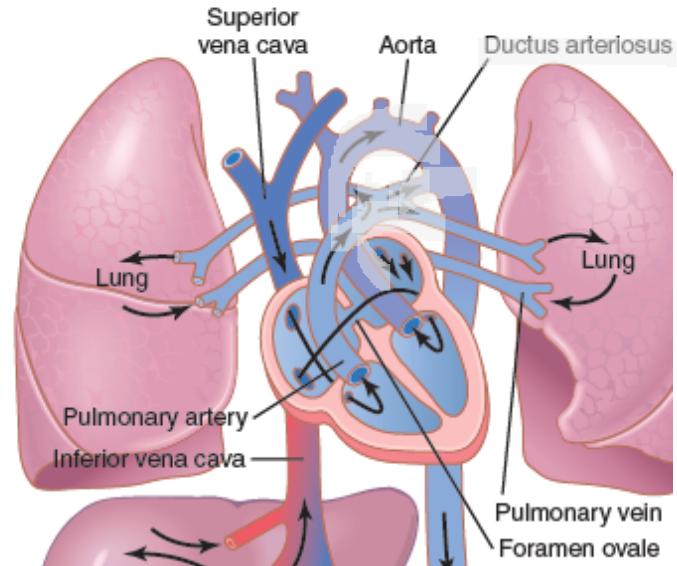
- The low right atrial pressure and the high left atrial pressure that occur secondarily to the changes in pulmonary and systemic resistances at birth cause blood now to attempt to flow backward through the foramen ovale; from the left atrium into the right atrium, (opposite to fetal life).



EXTRAUTERINE LIFE: CV

Closure of the Ductus Arteriosus

- The ductus arteriosus also closes due:
- The increased systemic resistance increases the aortic pressure while the pulmonary arterial pressure is reduced.
- Blood begins to flow backward from the aorta into the pulmonary artery through the ductus arteriosus, rather than in the other direction as in fetal life.
- high oxygen saturation (vasoconstriction)
- lower PGE2 (a vasodilator in fetus)
- failure of closure can be prevented by indomethacin



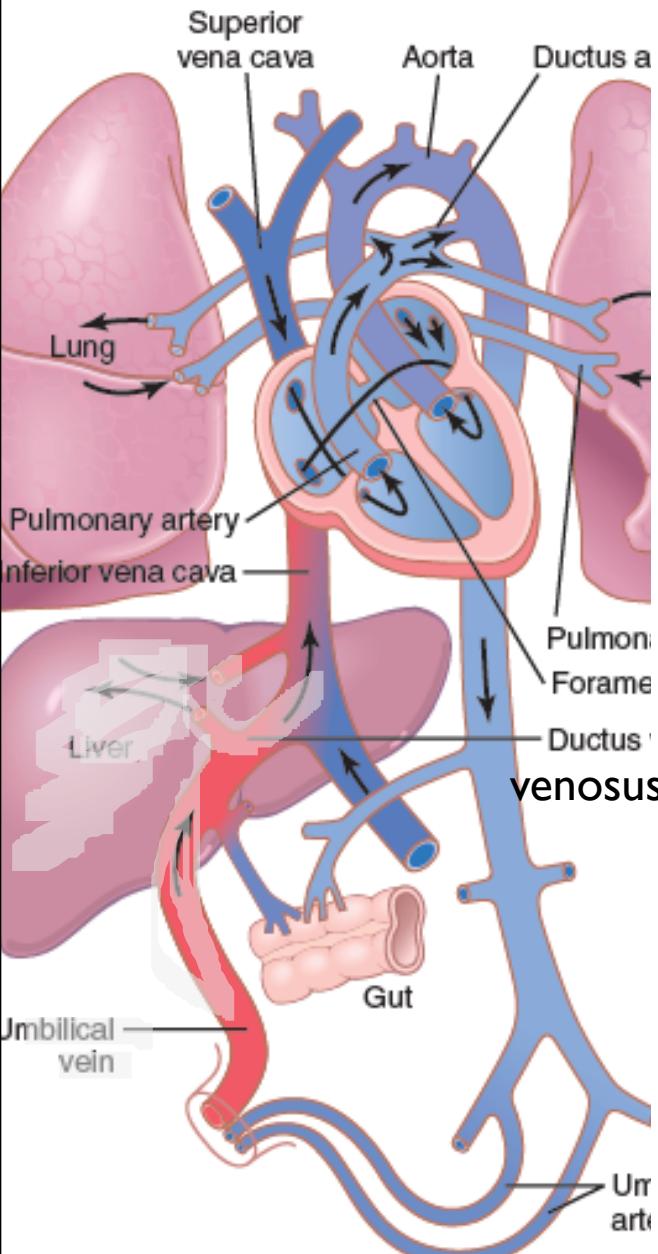


Figure 84-4. Organization of the fetal circula

EXTRAUTERINE LIFE

Closure of the Ductus Venosus

- Immediately after birth, blood flow through the umbilical vein ceases, but most of the portal blood still flows through the ductus venosus, with only a small amount .
- within 1 to 3 hours the ductus venosus contracts strongly and closes flow of portal thru ductus venosus.
- thus, the portal venous pressure rises from near 0 to 6 to 10 mm Hg, which is enough to force portal venous blood flow through the liver sinuses.



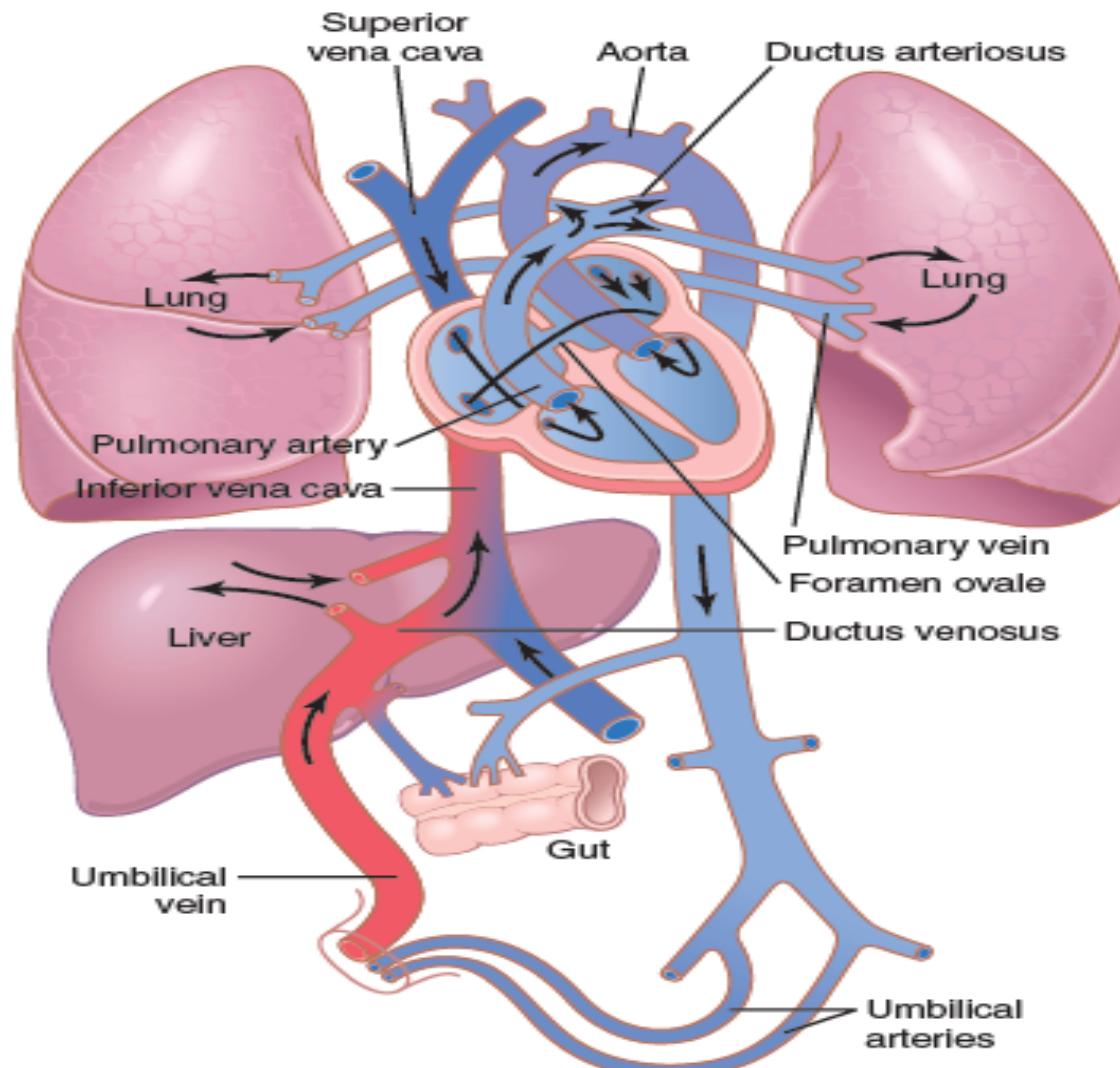


Figure 84-4. Organization of the fetal circulation.



EXTRAUTERINE LIFE

■ Respiratory System:

The normal rate of respiration in a neonate is about 40 breaths per minute, and tidal air with each breath averages 16 milliliters.



EXTRAUTERINE LIFE

Circulation:

- **Blood Volume.** The blood volume of a neonate immediately after birth averages about 300 milliliters, but if the infant is left attached to the placenta for a few minutes after birth or if the umbilical cord is stripped to force blood out of its vessels into the baby, an additional 75 milliliters of blood enters the infant, to make a total of 375 milliliters.



Extrauterine Life

- **Cardiac Output.**The cardiac output of the neonate averages 500 ml/min.
- **Arterial Pressure.**The arterial pressure during the first day after birth averages about 70 mm Hg systolic and 50 mm Hg diastolic; this increases slowly during the next several months to about 90/60.
- **Blood Characteristics.**The red blood cell count in the neonate averages about 4 million per cubic millimeter.



Extrauterine Life

Special Functional Problems in the Neonate

Neonatal Jaundice :

- the plasma bilirubin concentration rises from a normal value of less than 1 mg/dl to an average of 5 mg/dl during the first 3 days of life and then gradually falls back to normal as the liver becomes functional.
- physiologic hyperbilirubinemia.



Extrauterine Life

Digestion, Absorption, and Metabolism of Energy Foods and Nutrition:

The ability of the neonate to digest, absorb, and metabolize foods is same as that of the older child, with the following three exceptions.

1. secretion of pancreatic amylase in the neonate
is deficient, so that the neonate uses starch less adequately than do older children.
2. absorption of fats from the gastrointestinal tract is less than that in the older child
3. because the liver functions imperfectly during at least the first week of life, the glucose concentration in the blood is unstable and low.



Extrauterine Life Complications in preemies

Danger of Blindness Caused by Excess Oxygen Therapy in the Premature Infant:

- In Respiratory distress, use of oxygen therapy in treating prematurity.
- Too much oxygen stops the growth of new blood vessels in the retina. after oxygen therapy is stopped, new blood vessels burst all through the vitreous humor, blocking light from the pupil to the retina and then replaced by fibrous tissue.

