

Fetal and Neonatal Circulation

PG Semester II

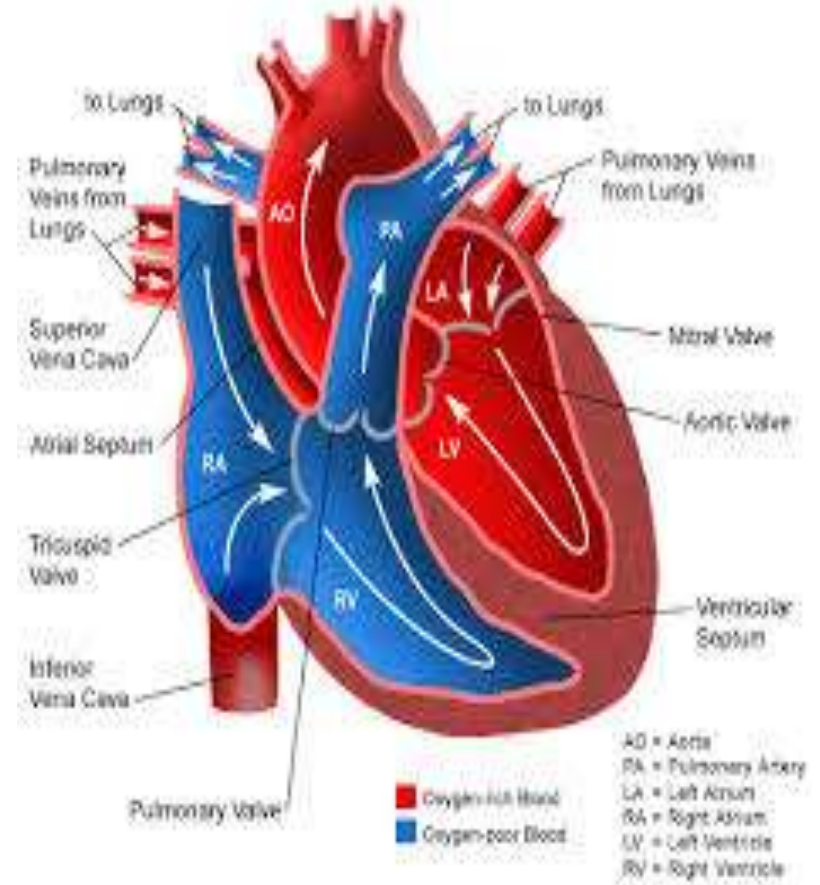
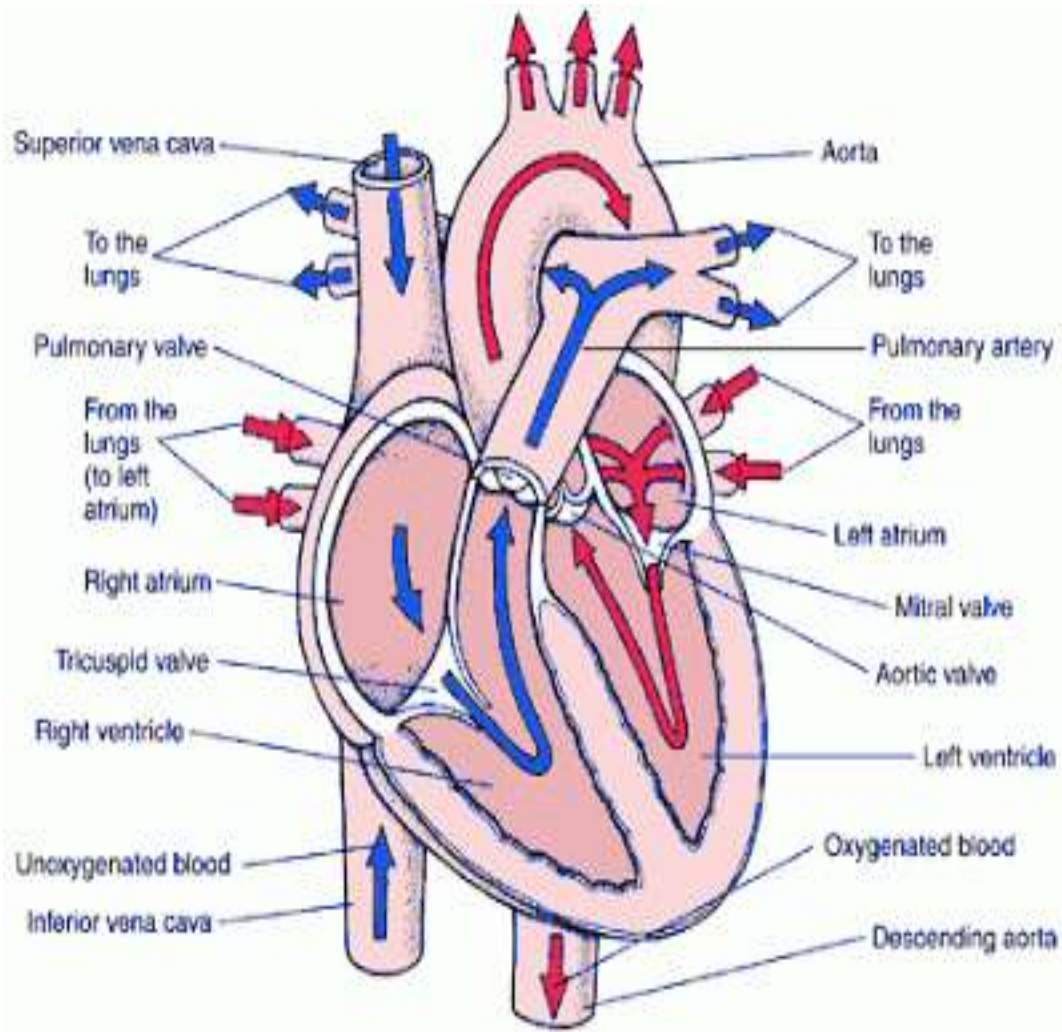


Figure: Blood route within adult human heart

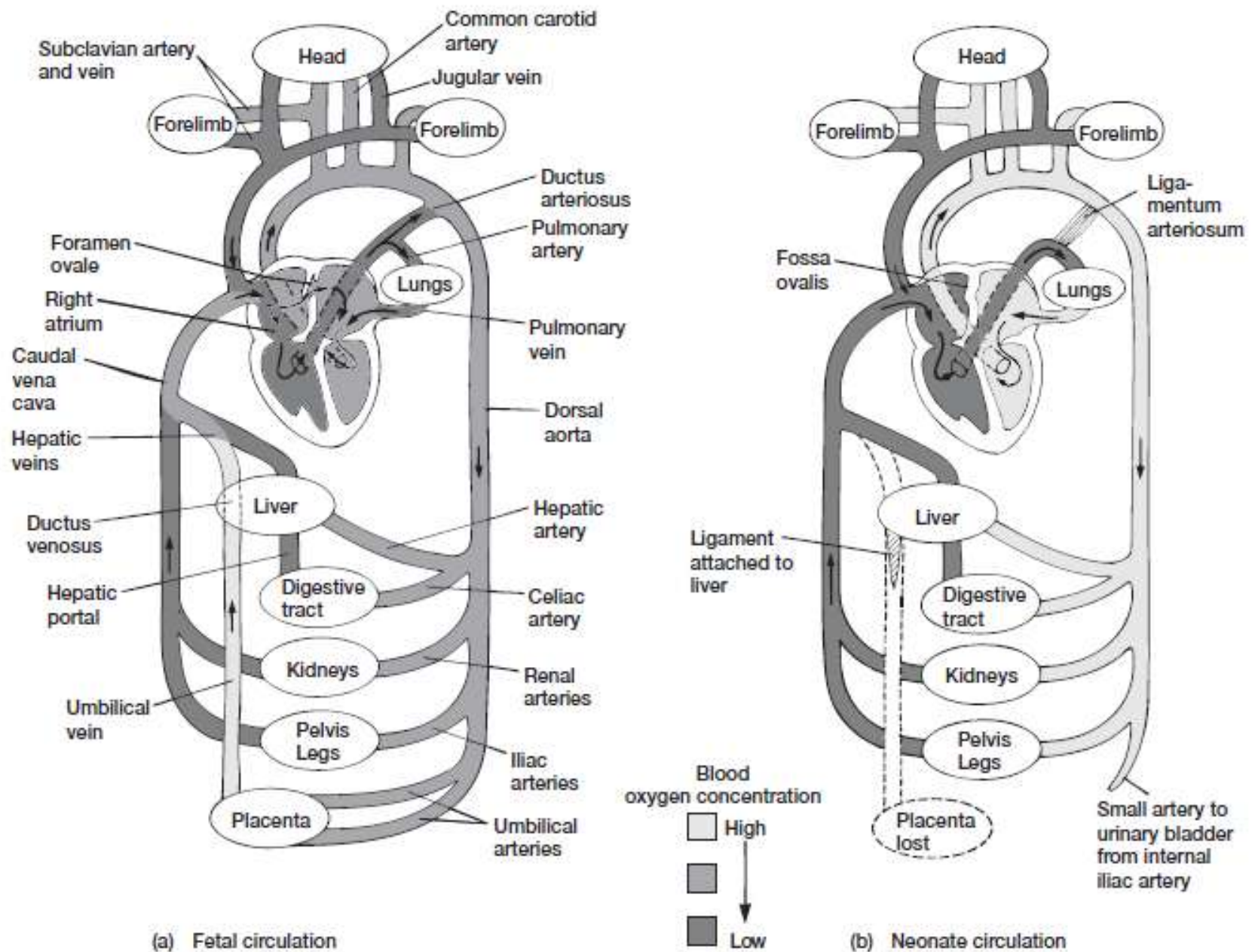


FIGURE 12.42 Mammalian (eutherian) circulatory changes at birth. (a) Fetal circulation. Because the lungs are nonfunctional, uptake of oxygen and nutrients occurs through the placenta. The ductus venosus is a liver bypass. The foramen ovale and ductus arteriosus are lung bypasses. (b) Neonatal circulation. Following birth, the lungs become functional, the placenta departs, and the ductus venosus, foramen ovale, and ductus arteriosus close.

Fetal Circulation in Placental Mammals-Main features

- In Eutherian mammals, the **fetus depends exclusively on the placenta for its oxygen supply.**
- Ductus Venosus- A single umbilical vein carrying oxygenated blood away from the placenta flows to the liver. **In the liver** approximately half the blood enters the sinusoids of the liver and the other **half bypasses the liver via the ductus venosus and enters the hepatic vein.**
- Ductus Arteriosus- Pulmonary circulation to the nonfunctional lungs is reduced. **About 90% of the blood that reaches the pulmonary artery bypasses the lung via ductus arteriosus.** Fetal lungs are collapsed and offer a higher resistance to blood passage than the systemic circuit. So most of blood flows through the ductus arteriosus to join the dorsal aorta.

- A mixed blood is distributed to the rest of the body and by the umbilical arteries, to the placenta.
- **Foramen Ovale- An opening between right and left atria, allows most blood entering right atrium to flow directly to the left atrium, without first passing through the lungs.**
- Note- In spite of this mixture in right atrium, maximum oxygenated blood from placenta tends to be shunted via foramen ovale. This shunted blood flows to left ventricle and then to carotid and head.

Neonatal Circulation- Changes at Birth

- **The maternal tissue separates from fetal tissue in the birth process**
- **Placenta is lost.**
- **Pressure within the circulatory system changes abruptly at birth. The lungs inflate and pulmonary resistance drops below systemic resistance.**
- **The neonatal lungs expand with the first vigorous breath and becomes functional for the first time.**
- Blood no longer flows through the umbilical vein as the source (Placenta) is cut. **Umbilical vein** persists only as a cord of connective tissue, the **ligamentum teres** .
- Smooth muscles within the walls of the umbilical vessels contract and gradually become invaded by fibrous connective tissues. This continues through the first two or three months of post natal life. **Occluded sections of the umbilical arteries become the lateral umbilical ligaments. Other sections of the umbilical arteries contribute to the common and internal iliac arteries.**
- Ductus Venosus – Over a two month period, the **ductus venosus atrophies into a fibrous mass, the Ligamentum Venosus.**

Neonatal Change-Continued

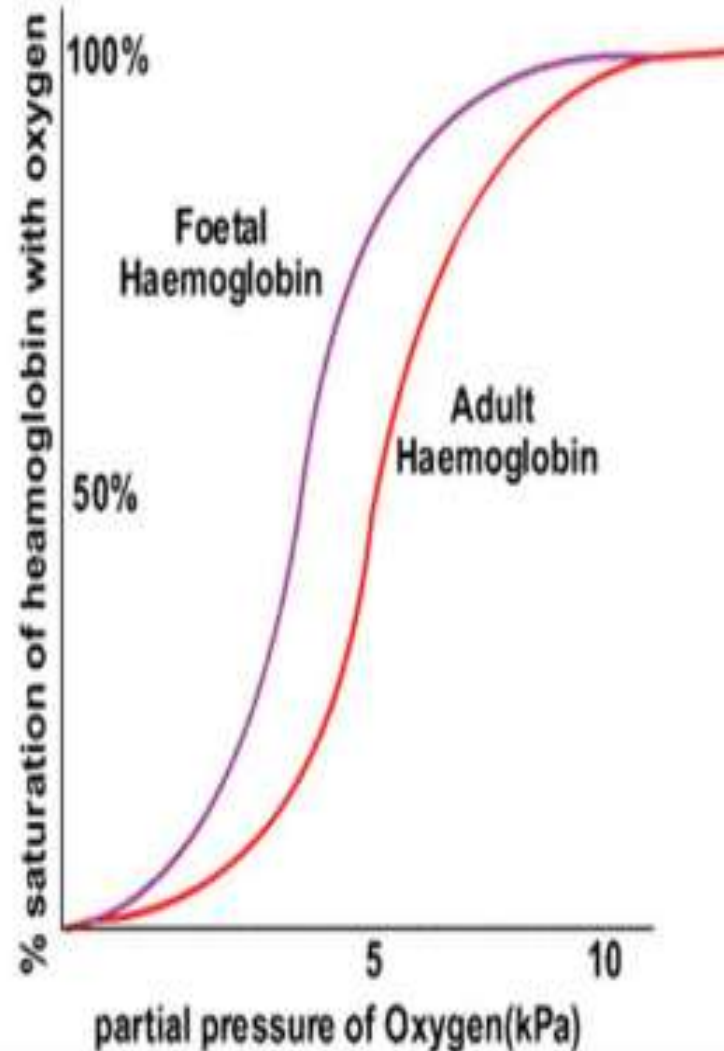
- Pressure within the circulatory system changes abruptly at birth. The lungs inflate and pulmonary resistance drops below systemic resistance. **Blood from the right ventricle now goes to the lungs rather than through the constricting ductus arteriosus to the body.** When breathing begins in the new born the sudden rise in the blood oxygen pressure stimulates contraction of smooth muscles in the walls of ductus arteriosus, immediately closing it. Over a period of several weeks, fibrous tissue invades the lumen and obliterates the **ductus arteriosus, which become a cord of tissue, the ligamentum arteriosum.**
- ALL BLOOD IN THE RIGHT ATRIUM NOW GOES TO THE RIGHT VENTRICLE AND LUNGS
- The return of a large volume of aerated blood from the lungs raises pressure in the left atrium sufficiently to hold the valve in the **foramen ovale** close. The interatrial valve grows onto the interatrial, but a depression, the **fossa ovalis**, remains throughout life.

Fetal Hemoglobin

- Hemoglobin A (Adult Hemoglobin) is composed of 2 alpha and 2 beta chains while Hemoglobin F is composed of 2 alpha and 2 gamma chains.
- Fetal Hemoglobin has greater affinity for oxygen as compared to adult Hb mainly to facilitate more oxygen supply to the developing fetus.
- Partial pressure of oxygen is very low in fetal tissue. Fetal hemoglobin has a higher affinity for oxygen in such low partial pressure as fetal hemoglobin is adapted to take up oxygen at relatively low tensions.
- However fetal hemoglobin does not unload oxygen in tissues as early as adult Hb, i.e., fetal Hb has a tendency to hang on its oxygen.

Fetal Hemoglobin

- Fetal hemoglobin has a higher affinity for O_2 at all partial pressures.
- This ensures that O_2 is transferred to the fetus from the maternal blood across the placenta.
- The PO_2 in fetal tissues is very low due to the high metabolic rate associated with fetal growth rates.
- Although fetal Hb has a higher affinity for oxygen in such a low partial pressure environment of the fetal tissue it unloads oxygen readily.
- At birth the foetal Hb is replaced with adult type Hb.



Neonatal Change of Hemoglobin

- **Change over occurs from fetal to adult types of hemoglobin.**
- NOTE- The ductus arteriosus remains open for a few hours or days after birth and continues to act as shunt. But since pulmonary resistance is so low, it recirculates some aerated blood to the lungs rather than diverting blood from them. This is of considerable physiological importance during neonatal period, when there is changeover from fetal to adult type of hemoglobin.
- As long as fetal hemoglobin still circulates in the newborn, the neonatal blood must become as thoroughly saturated with oxygen as possible to compensate for the greater tendency of fetal hemoglobin to hang on its oxygen. A recirculation of some aerated blood through the lungs accomplish this.
- **After the hemoglobin changeover has occurred ,ductus arteriosus contracts fully and adult circulatory pattern is established.** Eventually, the lumen of the **ductus arteriosus** is filled with connective tissue, and the **duct becomes the adult ligamentum arteriosus.**