

Fetal circulation & Amniotic fluid

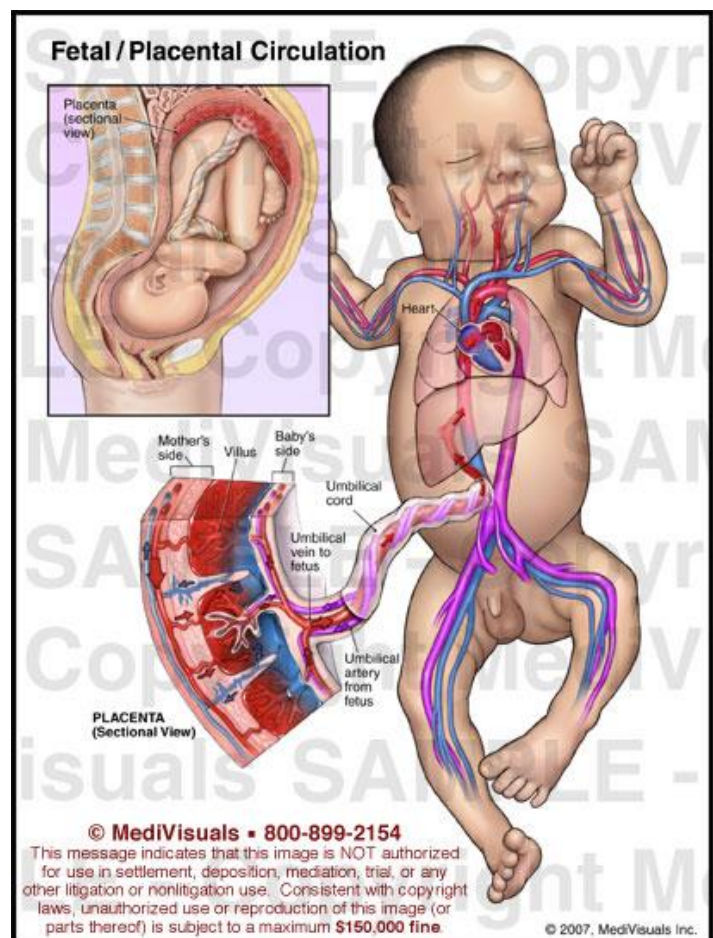
The fetal circulation :

The fetal circulation is quite different from that of the adult and functions smoothly until the moment of birth.

Its distinctive features are:

- Oxygenation occurs in the placenta.
- The right & left ventricle work in parallel rather than series.
- The heart, brain & upper body receive blood from the left ventricle (highly oxygenated blood), while the placenta & lower body receive blood from both Rt & Lt ventricle.

Oxygenated blood is brought from the placenta to the fetus by the umbilical vein (80%). The vein then divides into; the ductus venosus and portal sinus.



The **ductus venosus**, which is the major part and traverses the liver to enter the inferior vena cava directly. The ductus venosus doesn't supply oxygen to the intervening tissues, so it carries a well oxygenated blood (80%) directly to the heart.

In contrast the other division, the **portal sinus**, carries blood to the hepatic vein, where oxygen is extracted. This relatively deoxygenated blood from the liver then flows to the inferior vena cava, which also receives less oxygenated blood retaining from the lower part of the body.

Blood flowing to the heart from the inferior vena cava, therefore, consist of arterial-like blood that pass directly from the ductus venosus, and less oxygenated blood from the lower part of the body (below the diaphragm). The oxygen content of the blood reaching the heart (70%) is therefore less than that leaving the placenta.

The **well oxygenated** blood will enters the **left ventricle** (supply the heart and the brain). The **less oxygenated** blood enters the **right ventricle** (supply the rest of the body).

The two separate circulations are maintained by the structure of the **right atrium**, which effectively directs blood to the left atrium or the right ventricle depending on its oxygen content.

Once the blood enter the atrium, the configuration of the upper interatrial septum (**crista dividens**) is such that it shunts the well oxygenated blood to the left atrium and the less oxygenated to right ventricle.

This separation is also facilitated by the pattern of blood flow in the inferior vena cava, when the **well oxygenated** blood flow along the **medial aspect** and the **less oxygenated** blood along the **lateral aspect**, facilitating blood shunting to the opposite side of the heart.

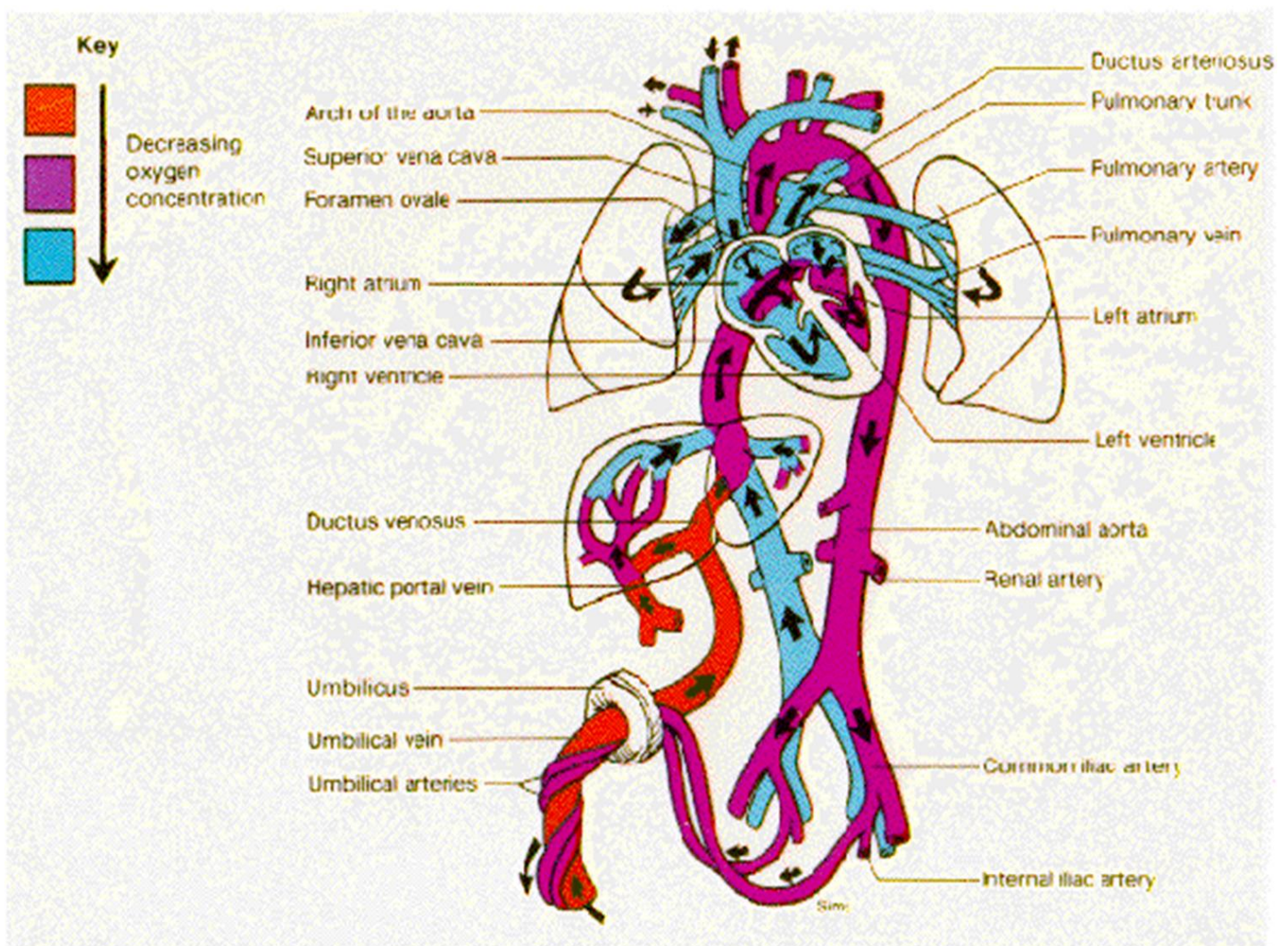
The well oxygenated blood pass from the right atrium to left atrium through the **foramen ovale**, & from thence it passes into left ventricle & out into the ascending aorta. By this arrangement the coronary arteries & the brain receive the most oxygenated blood.

Blood returning from the head & upper limbs through the **superior vena cava** streams towards the tricuspid valve to enter the **right ventricle**.

The **less oxygenated** blood coursing along the lateral aspect of the inferior vena cava, reaching the right atrium and then passes through the tricuspid valve to the right ventricle. The major part 87% of the right ventricle blood is shunted through the **ductus arteriosus to the descending aorta (60%)**.

On the other hand only 13% of the right ventricular out put is passed to the **lung**, this is because of high vascular resistance at the pulmonary circulation and lower resistance at the ductus arteriosus and the umbilical-placental vasculature.

About **1/3** of the blood flow through the ductus arteriosus pass to the **body**, and the other **2/3** is passed to the **placenta** through the two hypogastric arteries (distally become the umbilical artery) then the blood comes back from the placenta by the umbilical vein.



Changes in the fetal circulation after birth:

- After birth the **umbilical vessels, ductus arteriosus, foramen ovale, and ductus venosus** normally constrict or collapse. With the functional closure of the ductus arteriosus and expansion of the lung, the blood leaving the right ventricle will preferentially enter the pulmonary circulation to be oxygenated before it return to the left heart.
- The heart ventricles which was working in parallel will work in **series**.
- The distal portion hypogastric artery (**umbilical artery**) will be atrophied and obliterated within 3-4 days forming the umbilical ligaments.
- Intra-abdominal remnant of the umbilical vein form the **ligamentum teres**.
- Ductus venosus constrict by 10-96 hours after birth, anatomically become closed by 2-3 weeks (**ligamentum venosum**).

The oxygen supply to the fetus :

As the fetus grows it requires increasing amounts of oxygen. This is achieved by :

- ❖ Increase in placental transfer of **oxygen** due to reduction in the diffusion distance.
- ❖ Increase in the **Hb** contents of fetal blood .
- ❖ Fetal haemoglobin (**HbF**) (made in the liver and spleen not in the bone marrow) has different structure from adult HbA.

The amniotic fluid :

- The amniotic fluid has a mixed origin and has heterogeneous composition. It's slightly turbid from the mixture of solid particles derived from fetal skin and amniotic epithelium.
- May stained a green or brown if it contain meconium.

- The solid matter composed of lanugo hairs, epithelial cells, sebaceous material from the fetal skin, and cast-off amniotic epithelial cells.
- The volume of the amniotic fluid at term is about 800 ml (range 400-1500 ml).

10 weeks 30ml

12 weeks 50ml

20 weeks 300ml

30 weeks 600ml

The rate of increase is about 30ml/week. This rate decreases near term (the maximum amount relative to the fetal size is at 30 weeks).

- ❖ At term the specific gravity of the fluid is 1.010.
- ❖ It has organic, inorganic and cellular constituents. Some concentrations of important contents near term are:

sodium 130mmol/l

urea 3-4mmol/l

protein 3 g/l

lecithin 30-100mg/l

alpha-fetoprotein 0.5-5 mg /l

- It's mildly bacteriostatic, contains traces of steroid, non-steroid hormones and enzymes.
- pH = 7.

Production of amniotic fluid :

It's of both maternal and fetal origin, the relative importance of both mechanisms alters as pregnancy progresses.

- In **early pregnancy** it is from the maternal plasma (ultrafiltrate).
- By the **2nd trimester** diffusion through the fetal skin.
- **After 20 weeks**, the fetal kidneys play an increasing role in the production of the amniotic fluid. (at term 500ml/day).
- Pulmonary fluid contributes a small portion.

Disposal of the amniotic fluid :

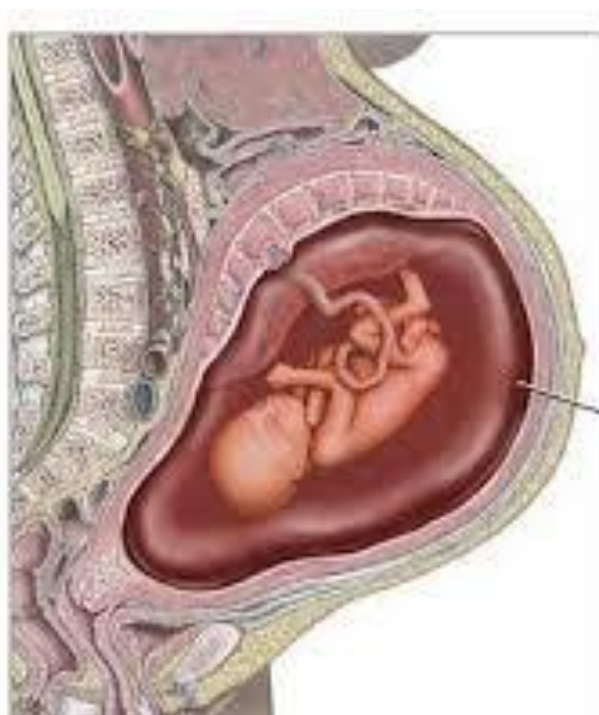
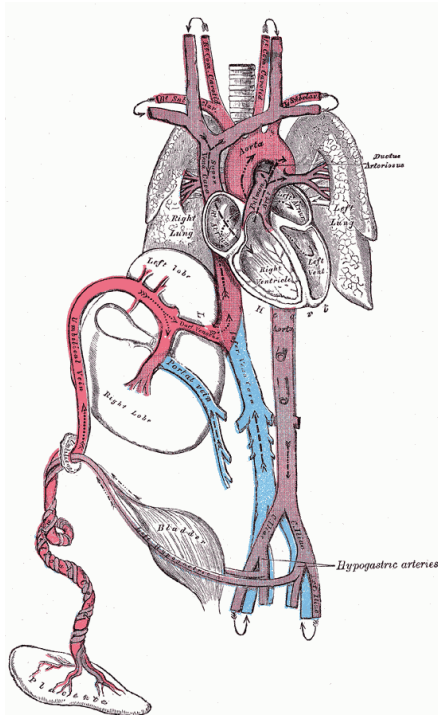
It's partly by the absorption through the amnion in to **maternal plasma** and partly **fetal swallowing** and absorption by the fetal intestine to enter the fetal plasma.

Functions of the amniotic fluid :

1. Guards the fetus against mechanical shocks, and equalizes the pressure exerted by uterine contractions.
2. Room for fetal movement.
3. Maintain the temp. of the fetus. so the fetus is not subjected to heat loss.
4. It can hardly regarded as a source of nutrition since it contain small amounts of salts and protein.(swallowing).
5. The forewater bag form a wedge which with uterine contraction dilates the internal os and the cervical canal.
6. At the rupture of the membrane during labour the fluid flushes the lower genital tract(aseptic and bactericidal).
7. The amnion produce a variety of bioactive compounds including vasoactive peptides, growth factors, and cytokines which modulates chorionic vessels flow or promotes cell replication and calcium metabolism.

Investigation of the amniotic fluid:

Samples of amniotic fluid can be obtained during pregnancy for various diagnostic purposes by abdominal amniocentesis, and a variety of chemical estimations for normal and pathological constituents can be made. Fetal amniotic cells can be obtained for tissue culture and chromosomal study.



Polyhydramnios
is excessive
amniotic fluid
surrounding
the fetus