Umbilical cord and fetal circulation

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Learning Objectives

- To be familiar with the fetal circulation,
- To be familiar with the specific shunts that ensure that the best oxygenated blood from the placenta is delivered to the fetal brain,
- To appreciate how the fetal circulation transitions at birth to an adult circulation.

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Anatomical Features of an Umbilical Cord

- The umbilical cord is a soft, tortuous cord with a smooth outer covering of amnion.
- It extends from the umbilicus of the fetus to the center of the placenta. Its length ranges from 50 cm to 60 cm, with a diameter of about 1 cm.[1]

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- Umbilical cord contain :[2]
- 2 umbilical arteries return non-oxygenated blood, fecal waste, CO2 to placenta
- 1umbilical vein brings oxygenated blood and nutrients to the fetus
- encloses the urachus (a remnant of allantois). The urachus is a fibrous remnant of the allantois that extends through the umbilical cord and is located in the space of Retzius between the peritoneum posteriorly and the transverse fascia anteriorly. The urachus serves as a drainage canal for the urinary bladder of the fetus

Function of an Umbilical Cord

- 1-The umbilical arteries carry deoxygenated blood from fetal circulation to the placenta.
- 2-The two umbilical arteries converge together about at 5 mm from the insertion of the cord, forming a type of vascular connection called the Hyrtl's anastomosis.[3] The primary function of Hartl's anastomosis is to equalize blood flow and pressure between the umbilical and placental arteries.[4] As the arteries enter the placenta, each bifurcates into smaller branches called the chorionic vessels.

Fetal circulation

- The fetal circulation is characterized by four shunts that ensure that the oxygenated blood from the placenta is delivered to the fetal brain. These shunts are the:[5]
- Umbilical circulation.
- Ductus venosus.
- Foramen ovale.
- Ductus arteriosus

Fetal circulation

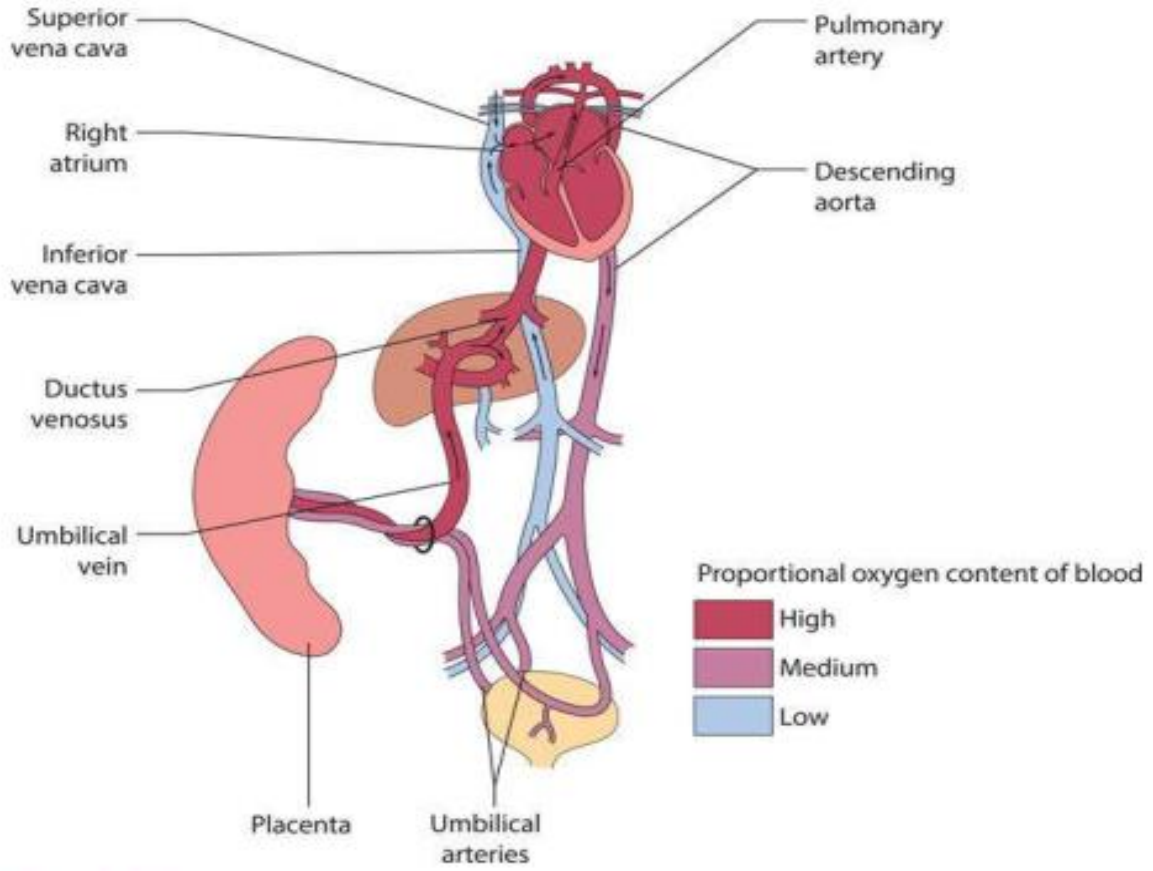

Figure 3.2 Diagrammatic representation of fetal circulation. (Adapted from Harrington K, Campbell S. *A Colour Atlas of Doppler Ultrasonography in Obstetrics*, London: Arnold, 1995.)

The difference between fetal and the adult circulation:[6]

- 1- The source of oxygenated blood is not the lung but the placenta.
- 2- Oxygenated blood from the placenta comes to the fetus through the umbilical vein, which joins the left branch of the portal vein. A small portion of this blood passes through the substance of the liver to the inferior vena cava, but the greater part passes directly to the inferior vena cava through the ductus venosus. A sphincter mechanism in the ductus venosus controls blood flow
- 3- The inferior vena cava carries the oxygen rich blood from the liver to the right atrium.

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- 4- The oxygen rich blood reaching the right atrium through the inferior vena cava is directed by the valve of the inferior vena cava towards the foramen ovale. Here it is divided into two portions by the lower edge of the septum secundum(crista dividens):
- a-Most of it passes through the foramen ovale into the left atrium.
- b– The rest of it gets mixed up with the blood returning to the right atrium through the superior vena cava, and passes into the right ventricle.
- 5- From the right ventricle, the blood (mostly deoxygenated) enters the pulmonary trunk. Only a small portion of this blood reaches the lungs and passes through it to the left atrium. The greater part is short – circuited by the ductus arteriosus into the aorta

The left atrium receives:[6]

- – Oxygenated blood from the right atrium, and
- – A small amount of deoxygenated blood from the lung
- The blood in this chamber is, therefore, fairly rich in oxygen. This blood passes into the left ventricle and then into the aorta. Some of this oxygen rich blood passes into the carotid and subclavian arteries to supply the brain, the head and neck and the upper extremities.
- The rest of it gets mixed up with poorly oxygenated blood from the ductus arteriosus. The parts of the body that are supplied by branches of the aorta arising distal to its junction with the ductus arteriosus, therefore, receive blood with only a moderate oxygen content

Cont.…

- Much of the blood of the aorta is carried by the umbilical arteries to the placenta where it is again oxygenatedQ and returned to the heart.
- So, from above explanation it is clear that oxygenated blood from placenta to the liver is carried by umbilical veins whereas from the liver to the heart it is carried by inferior vena cava

Changes in the circulation at Birth[5, 6]

- Soon after birth, several changes take place in the fetal blood vessels which lead to establishment of the adult type of circulation. The changes are as follows:
- 1-The muscle in the wall of the umbilical arteries contracts immediately after birth, and occludes their lumen. This prevents loss of fetal blood into the placenta.
- 2- The lumen of the umbilical veins and the ductus venosus is also occluded, but this takes place a few minutes after birth, so that all fetal blood that is in the placenta has time to drain back to the fetus

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- 3- The ductus arteriosus is occluded, so that all blood from the right ventricle now goes to the lungs, where it is oxygenated. The pulmonary vessels increase in size and, consequently, a much larger volume of blood reaches the left atrium from the lungs. As a result, the pressure inside the left atrium is greatly increased. Simultaneously, the pressure in the right atrium is diminished because blood from the placenta no longer reaches it. The net result of these pressure changes is that pressure in the left atrium now exceeds that in the right atrium causing the valve of the foramen ovale to close.
- 4- The vessels that are occluded soon after birth are replaced by fibrous tissue and form the following ligaments:

Vessel	Remnant
a. Umbilical Arteries	Medial Umbilical Ligaments[Q]
b. Left umbilical vein	Ligamentum teres of the liver[Q]
c. Ductus venosus	Ligamentum venosum[Q]
d. Ductus arteriosus	Ligamentum arteriosum[Q]

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