

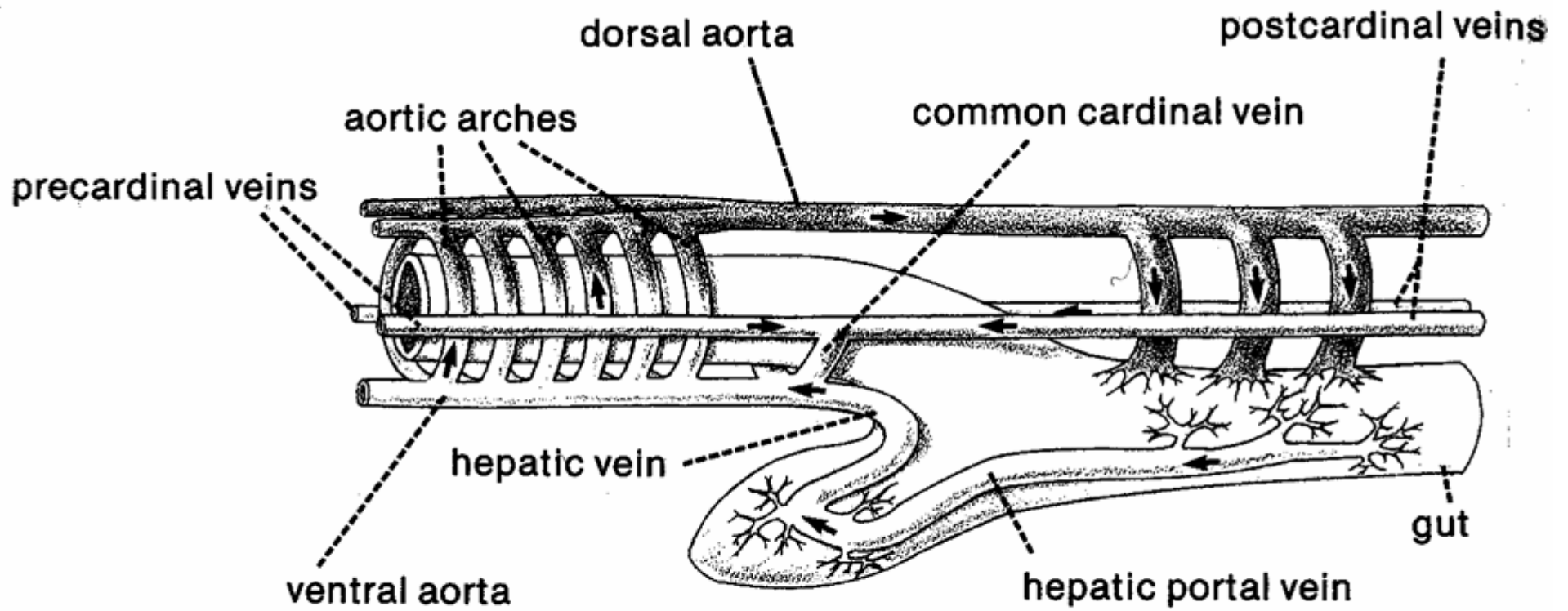
Biology 224

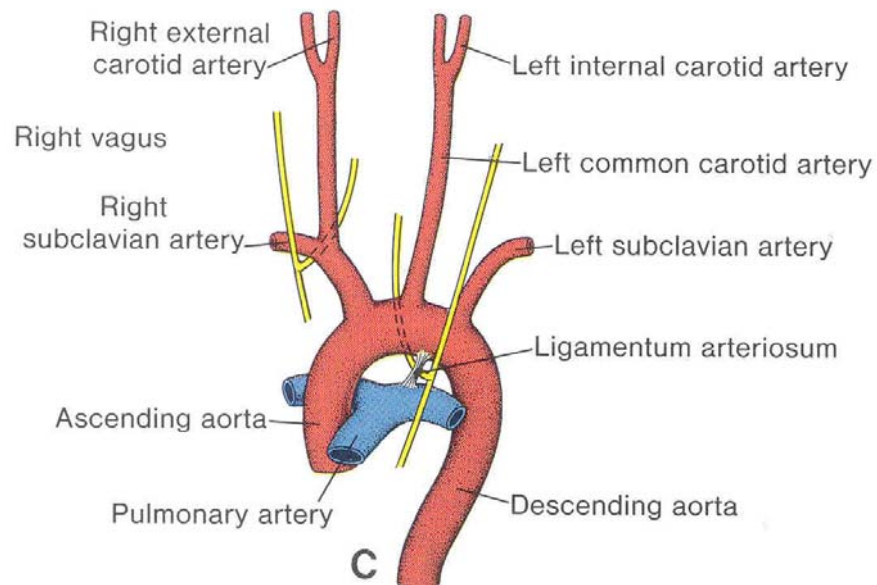
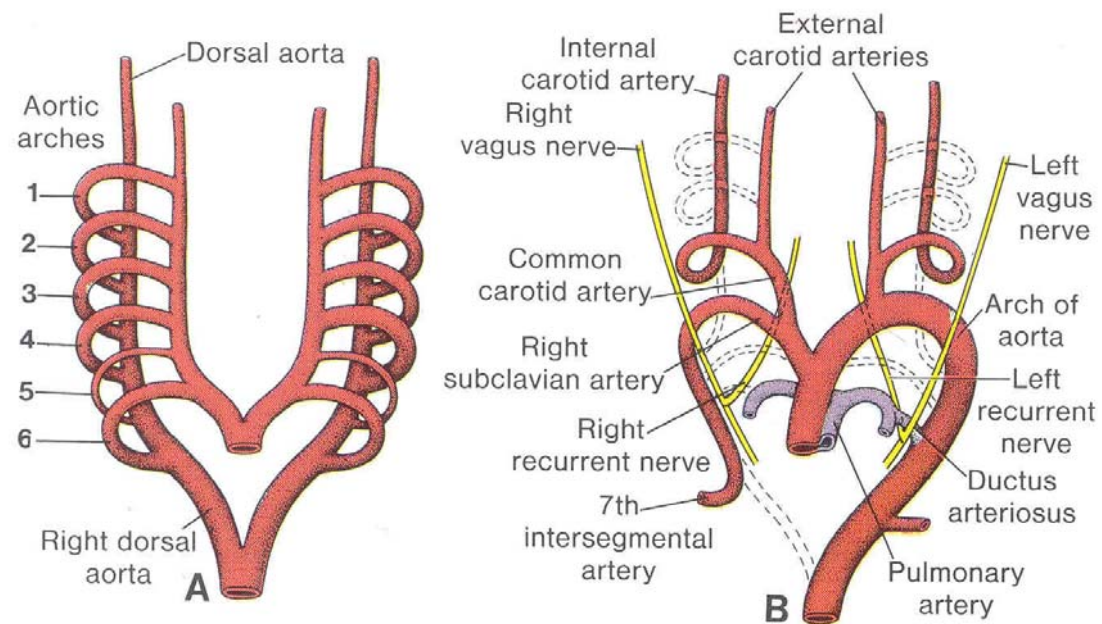
Human Anatomy and Physiology II

Week 4; Lecture 1; Monday

Dr. Stuart S. Sumida

Changes in the Circulatory and Respiratory Systems at Birth





FETAL RESPIRATORY & CIRCULATORY CONDITIONS

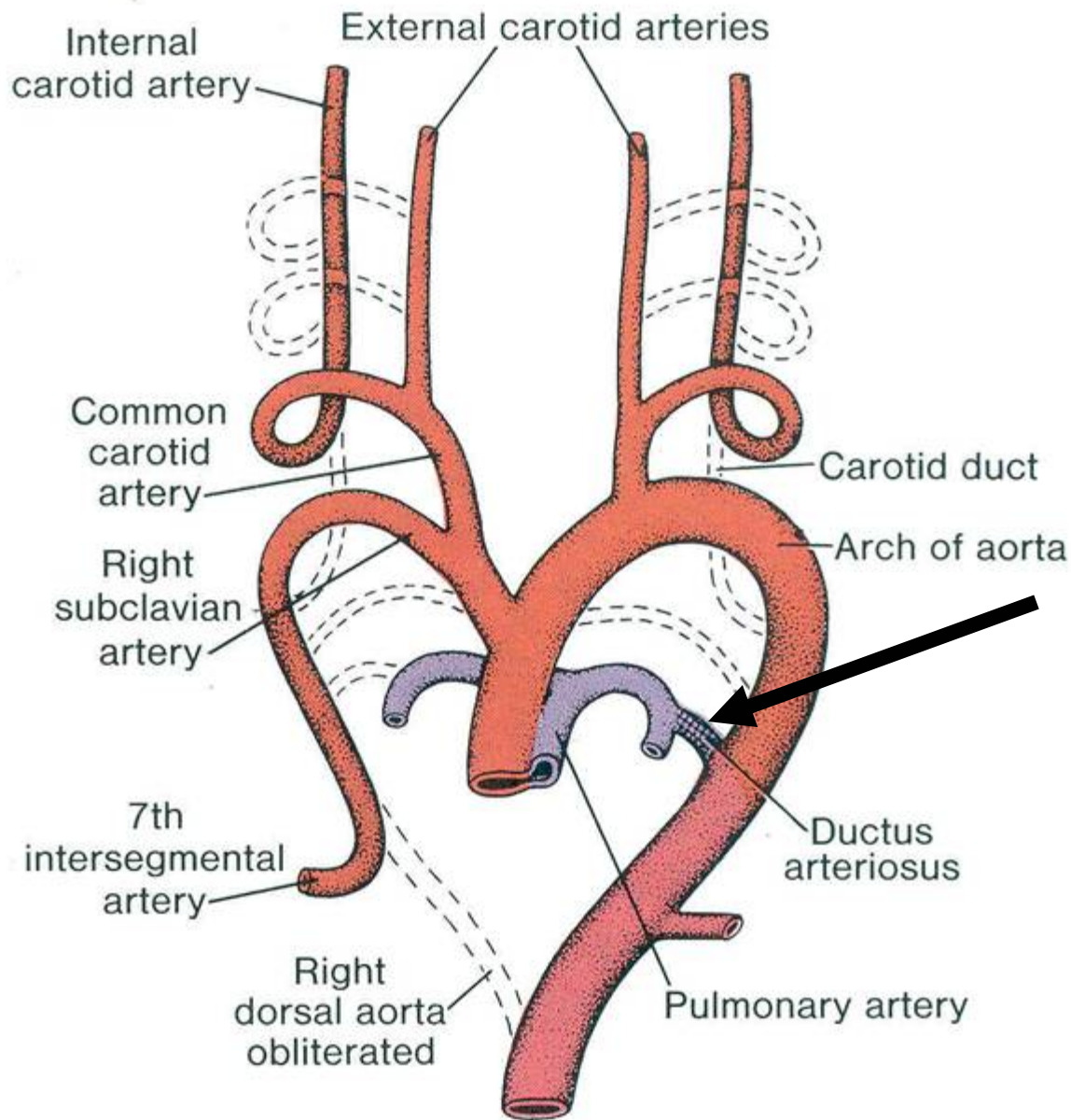
- Lungs small and collapsed.
- Lungs filled with amniotic fluid.
- Lung volume too small to allow complete output of right atrium through lung circuit.
- (Another way of saying this: Back-pressure of lungs too great to allow much blood flow through lungs.)
- There is enough blood flow to allow growth and development, but not gas transfer.
- No need for gas transfer in lungs while *in utero*.

So...

Before birth, it would be desirable for blood leaving the right atrium to – for the most part – bypass the lung. There are two ways:

1st: This is done via a structure called the DUCTUS ARTERIOSUS. The DUCTUS ARTERIOSUS is a connection between the sixth aortic arch (Pulmonary Arch) on the LEFT side and the arch of the aorta (also on the left side).

2nd: The FORAMEN OVALE is a hole between the right and left atria, allowing blood to pass from the right side to the left and not ever get pumped to the lungs.



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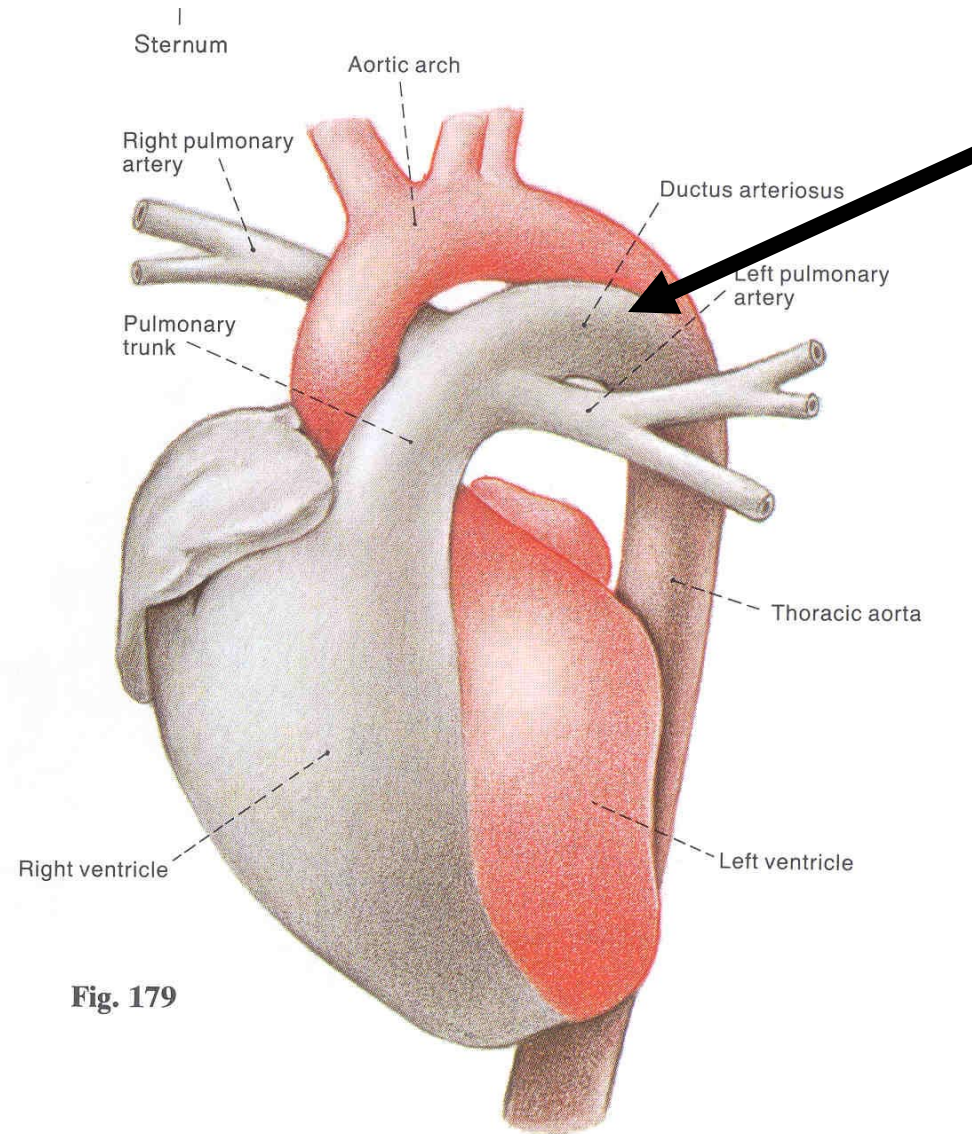


Fig. 179

The Ductus Arteriosus in the Neonatal Heart ▲

NOTE that the blood in the thoracic aorta is a mixture, part of it coming from the right heart by way of the ductus arteriosus and part of it coming from the left heart through the aorta.

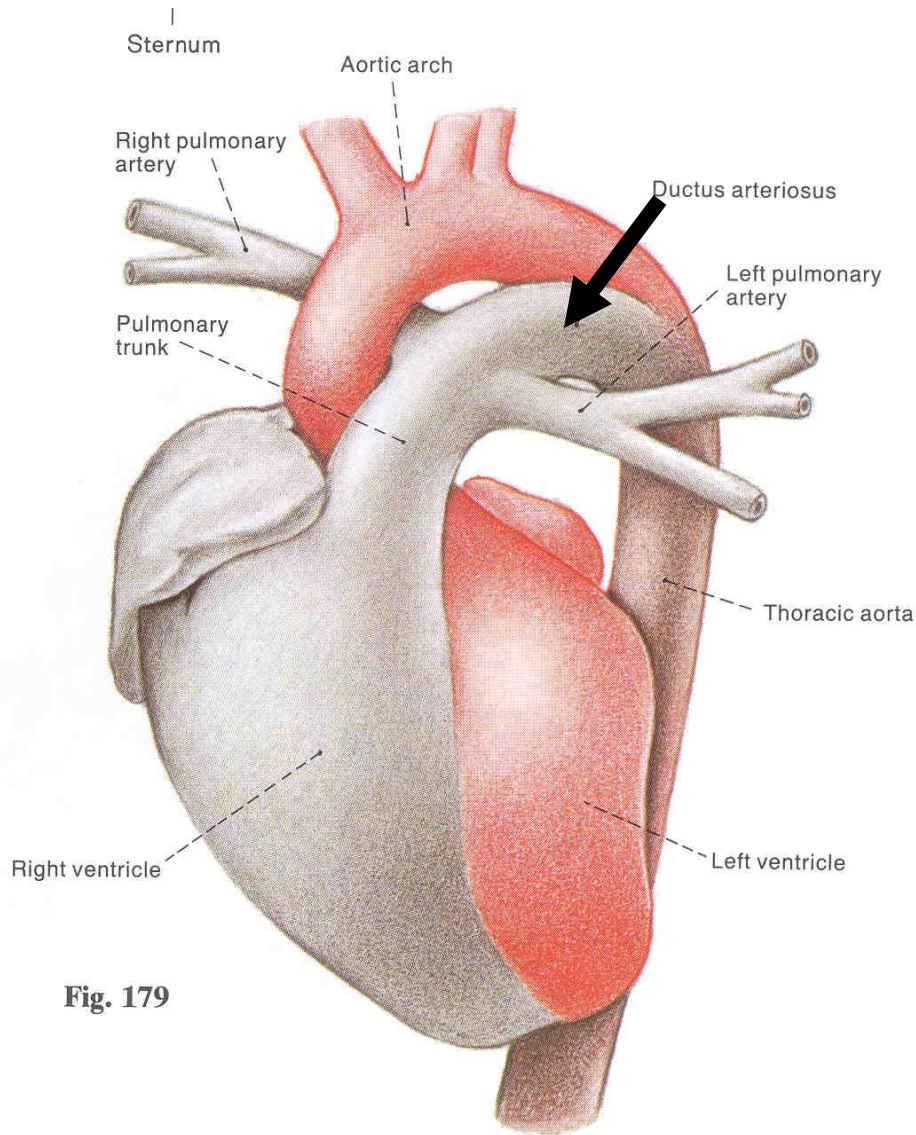


Fig. 179

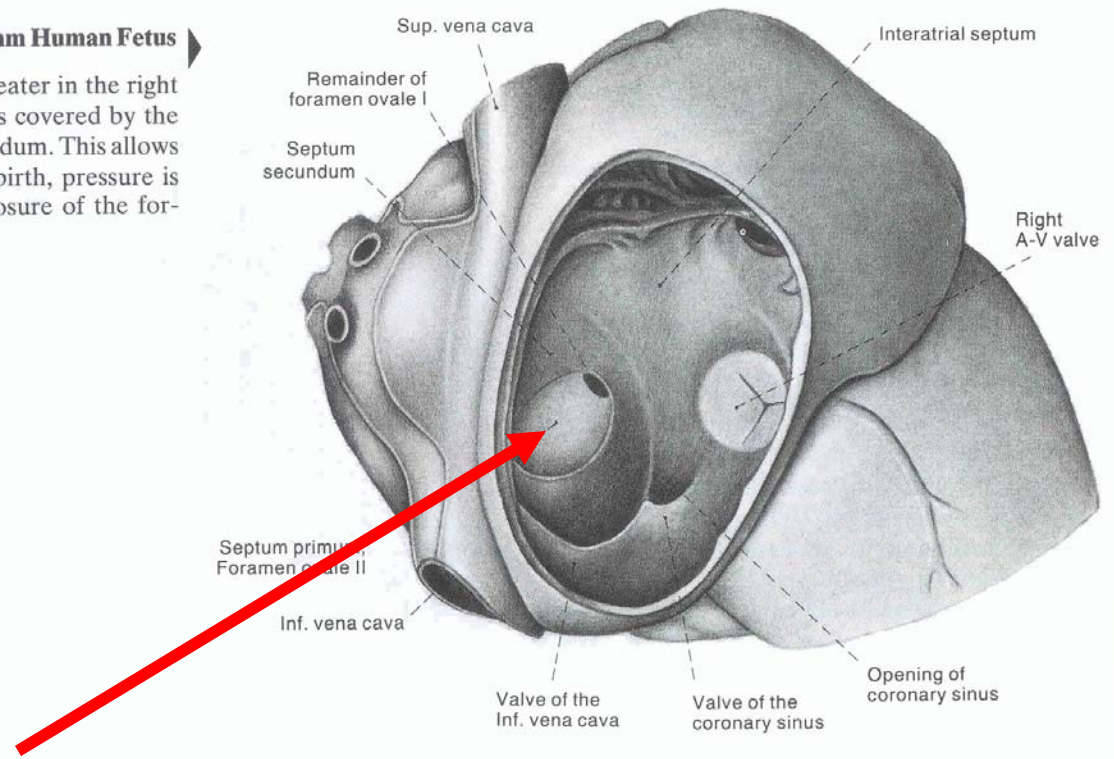
The Ductus Arteriosus in the Neonatal Heart

NOTE that the blood in the thoracic aorta is a mixture, part of it coming from the right heart by way of the ductus arteriosus and part of it coming from the left heart through the aorta.

The DUCTUS ARTERIOSUS allows blood to skip past the lungs and join up with the partially oxygenated blood that is being pumped out of the left ventricle.

The Opened Right Atrium in a 310 mm Human Fetus

NOTE that in the fetus blood pressure is greater in the right atrium than in the left and foramen ovale II is covered by the septum primum on the left side of septum secundum. This allows blood to pass easily from right to left. After birth, pressure is greater in the left atrium, which results in closure of the foramen.



The FORAMEN OVALE is a hole between the right and left atria, allowing blood to pass from the right side to the left and not ever get pumped to the lungs.

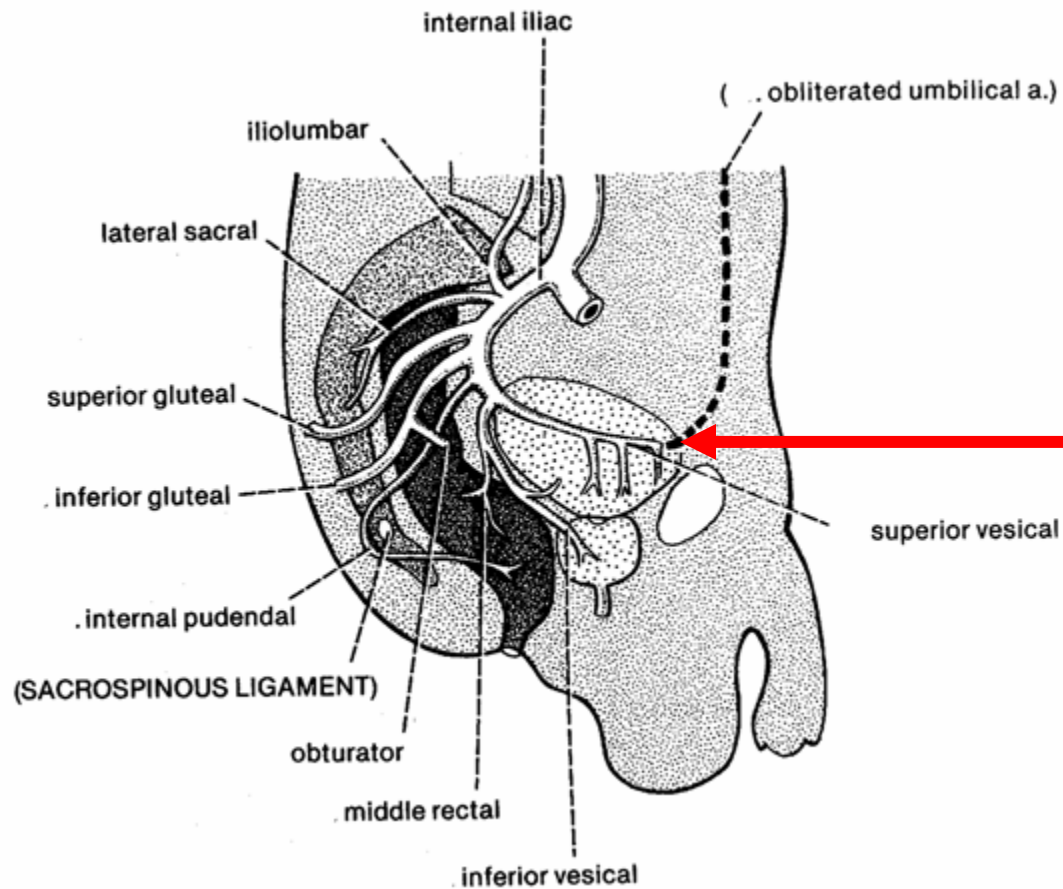
So...

...where does spent blood from the fetus go?

Well, mom of course. It goes to mom via the UMBILICAL VEIN.

Remember that the distal end of the internal iliac vein is the old connection of the UMBILICAL VEIN which goes toward the placenta.

Branches of the Internal Iliac Artery (In order)



1. Iliolumbar
2. Lateral sacral
3. Superior gluteal
4. Inferior gluteal
5. Internal pudendal
6. Obturator
7. Middle rectal
8. Inferior vesicle
9. Superior vesicle
10. The old umbilical artery connects to end of internal iliac.

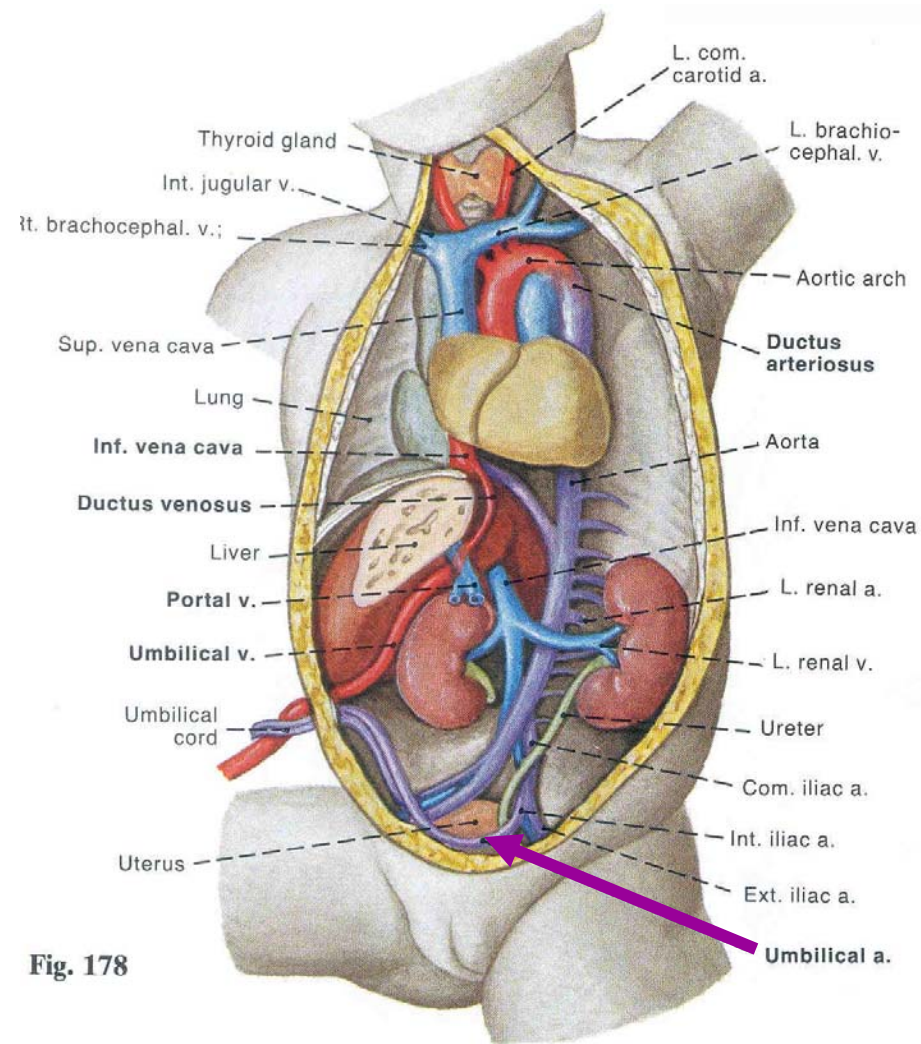


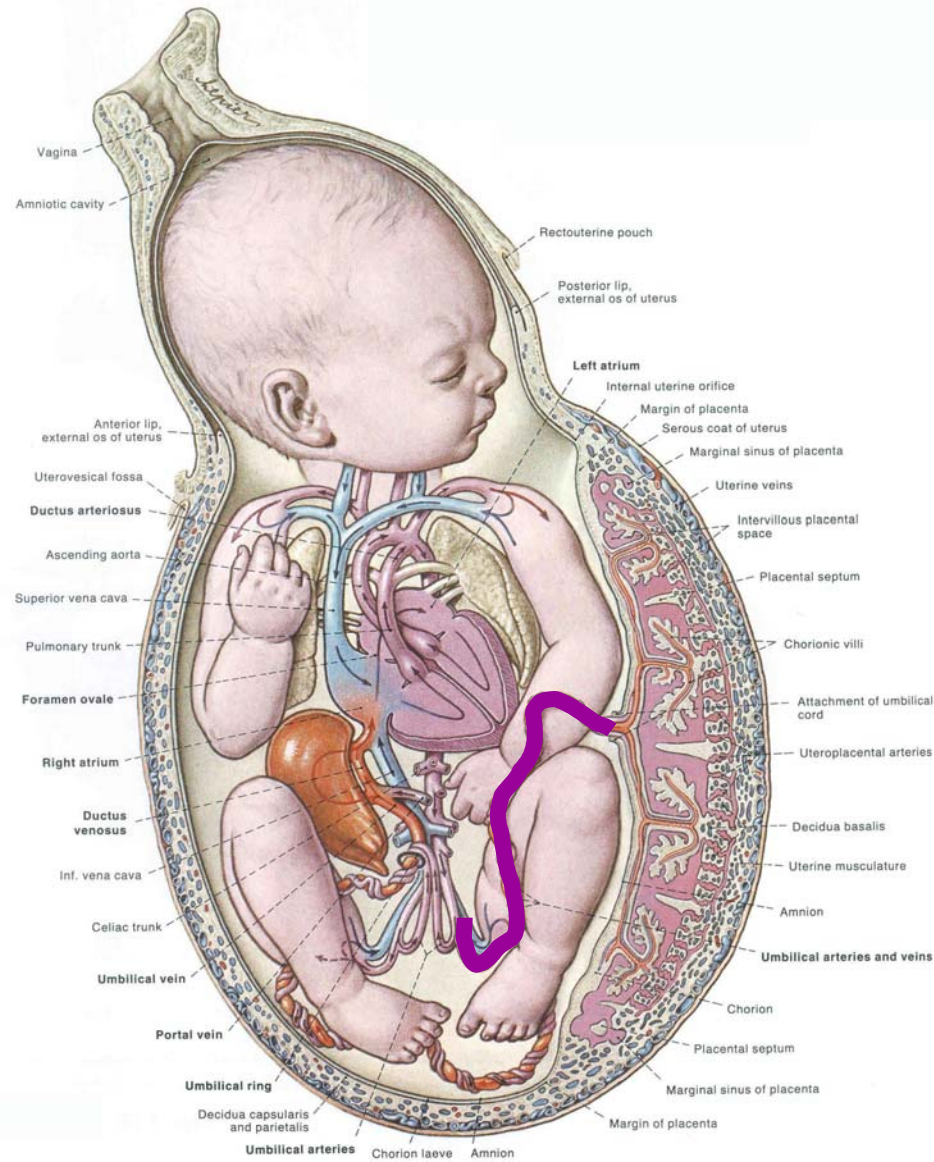
Fig. 178

Fetal Circulation in the Newborn Female

NOTE that the shades of color depict the oxygen level in the blood. Observe the umbilical vein, ductus arteriosus and umbilical artery – all structures peculiar to fetal circulation.

Circulation in the Fetus

NOTE: 1) that some oxygenated blood from the umbilical vein flows through the foramen ovale to the left ventricle and out the aorta to the head and limbs. A considerable amount of oxygenated blood also goes through the right ventricle, pulmonary trunk, and then through the ductus arteriosus to the aorta.
2) the shunt formed by the ductus venosus to bypass the liver.



Arterial blood from mother & placenta – laden with nutrients and oxygen – come to fetus via (now) the umbilical vein hooked up to the inferior vena cava.

Thus, the blood returning to the fetal heart is actually, partially oxygen and nutrient rich.

This sets up the potential problem of it mixing in the right atrium with deoxygenated blood returning from the superior vena cava.

HOWEVER: Due to the angle of entry of the blood from the inferior vena cava and superior vena cava, their streams do not mix much.

MORE OXYGEN-RICH BLOOD FROM INFERIOR VENA CAVA
PASS THROUGH FORAMEN OVALE OVER TO THE LEFT SIDE.

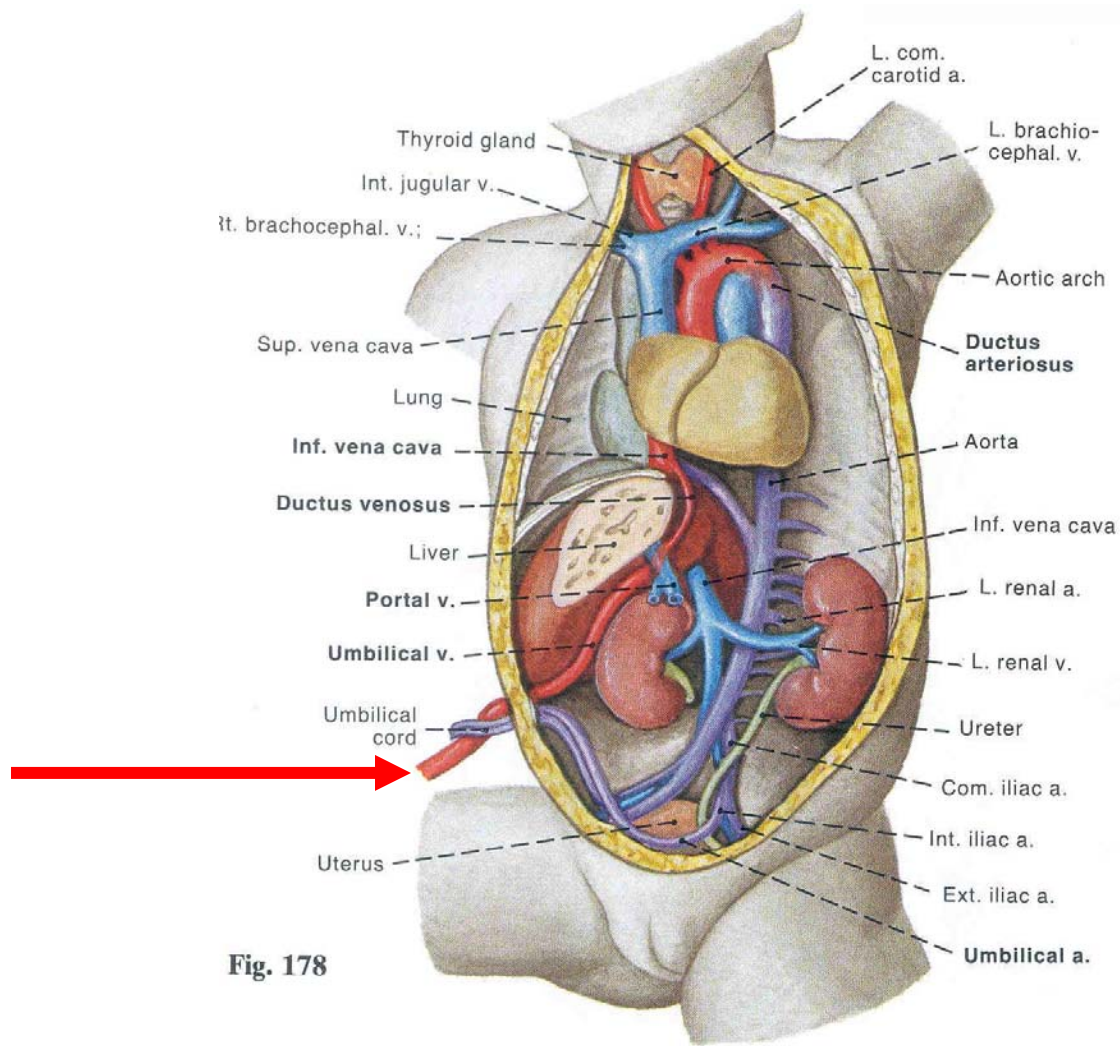


Fig. 178

Fetal Circulation in the Newborn Female

NOTE that the shades of color depict the oxygen level in the blood. Observe the umbilical vein, ductus arteriosus and umbilical artery – all structures peculiar to fetal circulation.

From left atrium, moderately oxygen-rich blood passes to left ventricle and then out arch of aorta.

Blood richest in oxygen & nutrients goes to heart wall, head (brain), neck, and arms.

Somewhat more oxygen/nutrient depleted blood from superior vena cava – of course – enters right atrium, then right ventricle, then pulmonary artery.

MOST of the right ventricular blood exits via the left pulmonary arterial branch – then to the **DUCTUS ARTERIOSUS**.

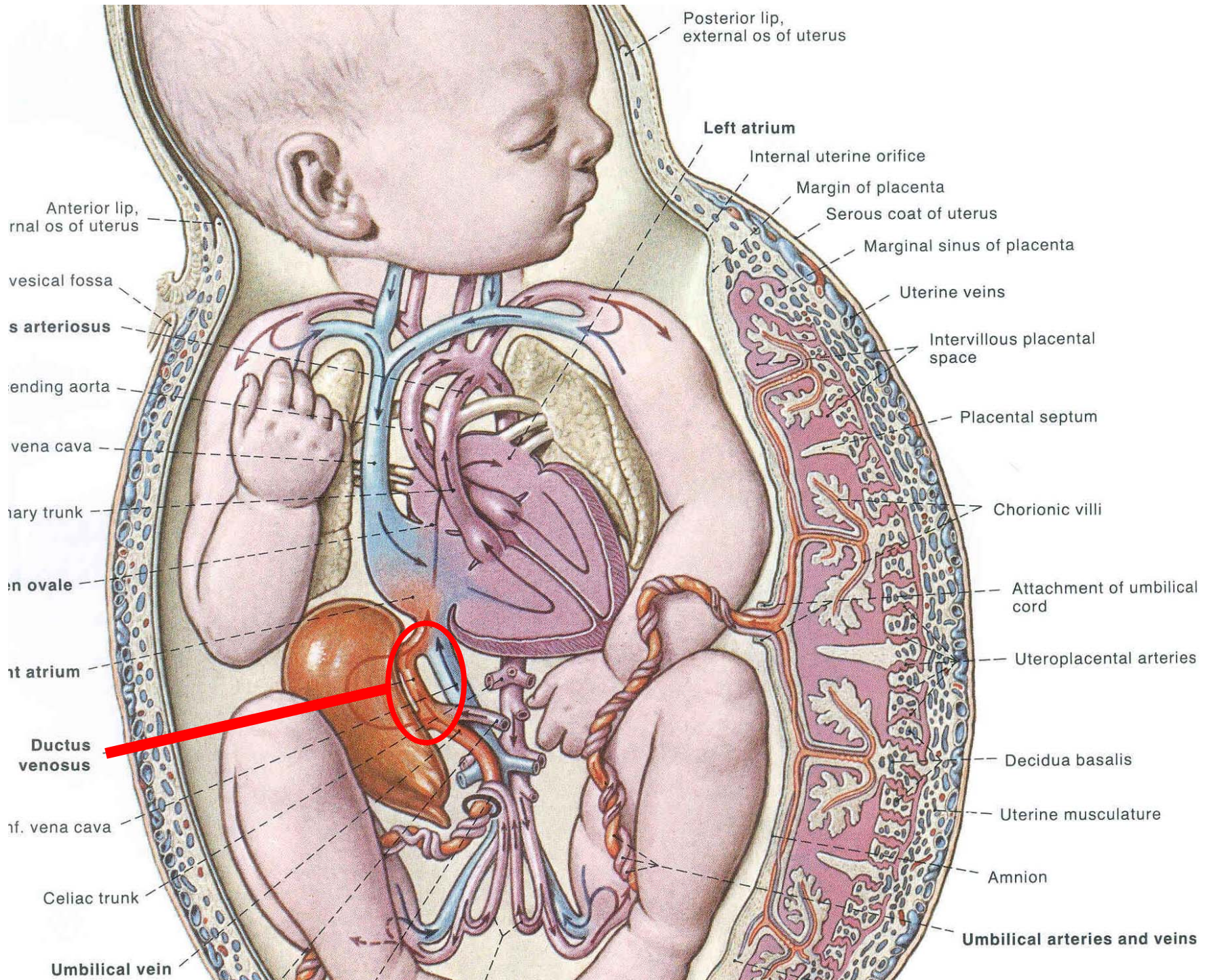
This means that it eventually mixes with somewhat richer blood in the descending aorta, but **ONLY AFTER** the aorta has delivered blood to head, neck, and arms.

MORE ON GETTING FRESH BLOOD IN...

Remember, UMBILICAL VEINS enter the inferior vena cava. But soon, they hook up with the hepatic portal system.

The right UMBILICAL VEIN eventually degenerates, leaving only the left.

It would not be desirable to mix oxygenated blood (from mom, umbilical vein) with deoxygenated in liver. So – a new pathway from the placenta to the upper region of the inferior vena cava bypasses the liver. It is called the **DUCTUS VENOSUS**. It runs straight from the portal vein, bypassing the liver, to the inferior vena cava.



CIRCULATORY CHANGES AT BIRTH – I

Things that need to be changed:

1. If fetal circulatory pattern were to persist after birth, right atrial blood would continuously spill to the left side via the foramen ovale.
2. Blood of the pulmonary arch would miss the lung and go to the aorta, mixing there.
3. This would result in hypoxia – lack of adequate oxygen in arterial blood.
4. Lungs would be bypassed continuously, deteriorating quickly.

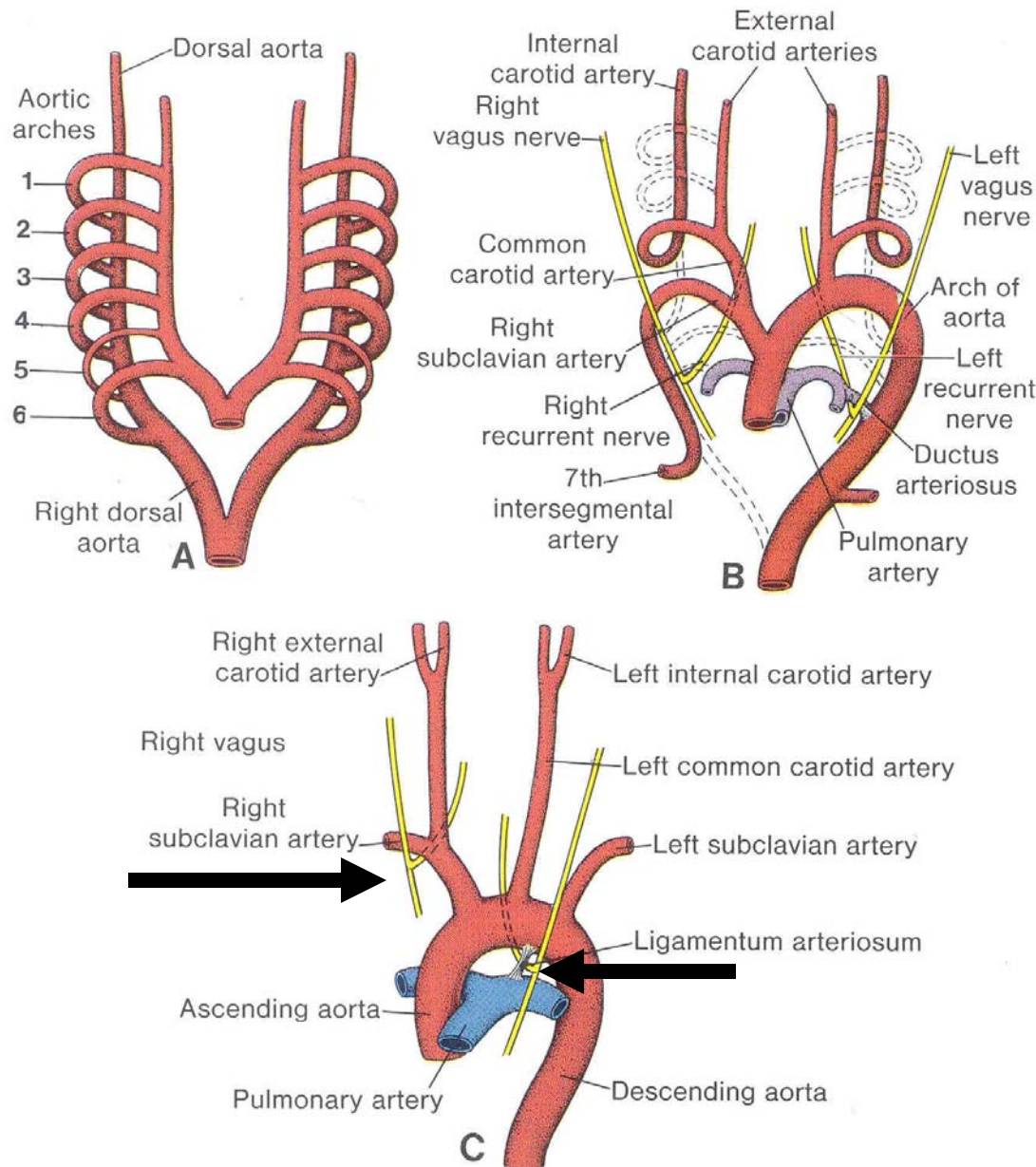
To prevent this, foramen
ovale and ductus arteriosus
**MUST CLOSE AT THE
MOMENT OF BIRTH.**

CIRCULATORY CHANGES AT BIRTH – II

1. In the fetus, foramen ovale is covered by an **interatrial flap valve** that allows blood to pass from right to left atrium, but not in opposite direction.
2. After child is delivered, fetal blood vessels in placenta contract, returning blood they contain (about 100 milliliters) to the infant.
3. Child takes first breath. Lung capillaries fill with blood. The first pulse of oxygenated blood returns from lungs to left atrium with next heartbeat.
4. As a result of suddenly higher flood of blood INTO left atrium, **PRESSURE IN THE LEFT ATRIUM IS NOW HIGHER THAN THAT IN THE RIGHT**. The increased pressure holds the **interatrial flap valve** shut – thus **CLOSING FORAMEN OVALE**.

CIRCULATORY CHANGES AT BIRTH – III

5. At moment of first breath, a powerful VASOCONSTRICTION closes the ductus arteriosus. (In a few days fibrous tissue begins to occlude it; in adult, it is left as a ligament, the LIGAMENTUM ARTERIOSUM.)
6. When blood stops flowing in from placenta via umbilical vein, ductus venosus closes off.
7. In a few days fibrous tissue begins to occlude it; in adult, it is left as a ligament, the LIGAMENTUM VENOSUM. The umbilical vein become the ROUND LIGAMENT OF THE LIVER (also known as “ligamentum teres”).
8. Together, ligamentum venosum and round ligament tie postnatal portal vein to navel ventrally and inferior vena cava dorsally.

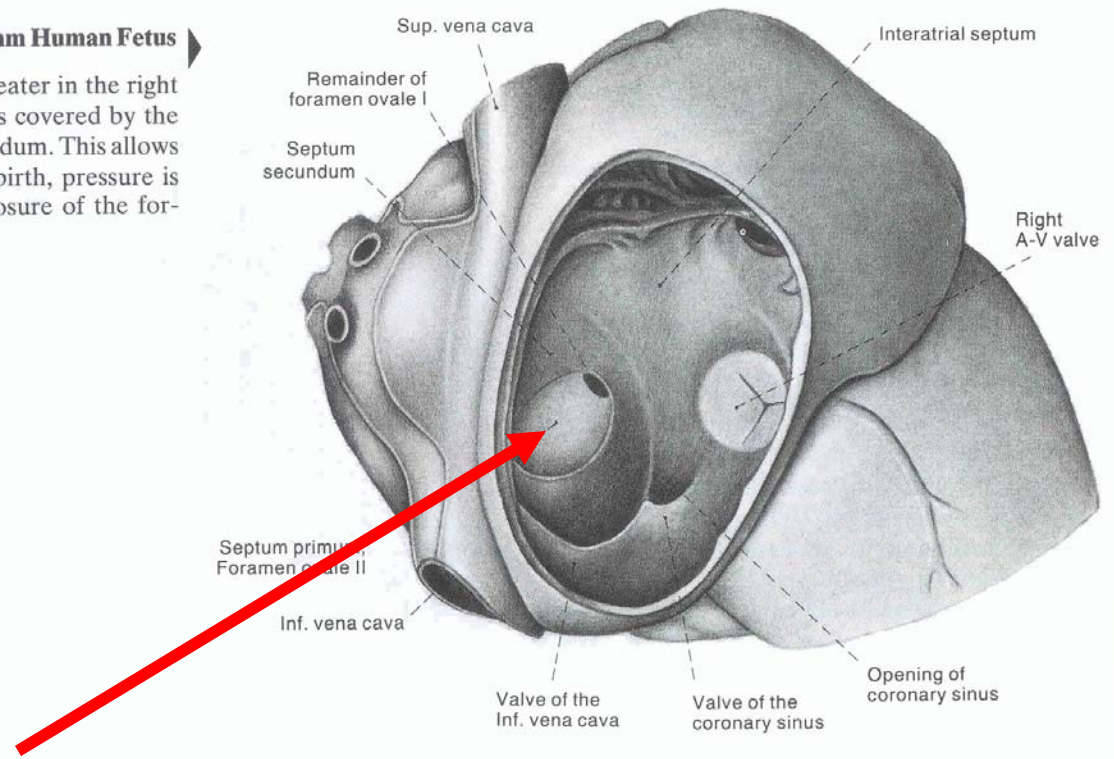


The **LIGAMENTUM ARTERIOSUM** persists in the adult.

Note that this means the branch of the vagus nerve that hooked around it must **STILL** hook around it (**LEFT RECURRENT BRANCH OF THE VAGUS NERVE**), whereas the **RIGHT RECURRENT BRANCH OF THE VAGUS NERVE** hooks around the right subclavian artery.

The Opened Right Atrium in a 310 mm Human Fetus

NOTE that in the fetus blood pressure is greater in the right atrium than in the left and foramen ovale II is covered by the septum primum on the left side of septum secundum. This allows blood to pass easily from right to left. After birth, pressure is greater in the left atrium, which results in closure of the foramen.



Eventually, the interatrial flap covering the **FORAMEN OVALE** fuse with the interatrial wall.

(If foramen remains open, inappropriate blood mixing takes place – “Blue Baby”.)

OTHER CHANGES AT BIRTH – HEMOGLOBIN FUNCTION

Due to fetal mixing of blood, FETAL HEMOGLOBIN is adapted specially.

FETAL HEMOGLOBIN can combine with oxygen even more easily than ADULT HEMOGLOBIN – so it can pick oxygen OFF of the adult hemoglobin.

This special property is lost within a few days after birth.

CHANGES NEAR BIRTH – LIVER FUNCTION

At approximately week 27-30, enzyme function in the fetal liver changes to promote storage of GLYCOGEN.

This stores up glycogen as a food source in case of temporary starvation between birth and mother's first ability to produce milk for nursing.