

Fetal Circulation

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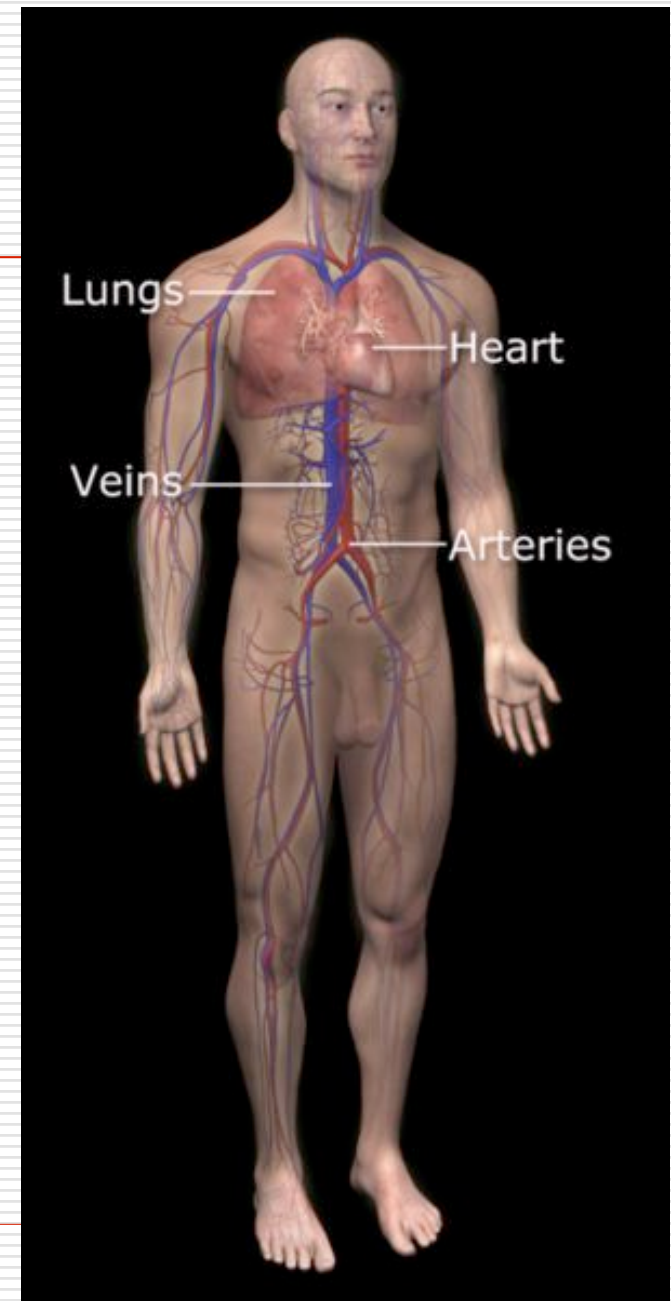
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Fetal Circulation: Key Topics

- Placenta (blood contact with mother)
 - Fetal Hemoglobin (HbF)
 - Anatomic differences from adult
 - Congenital abnormalities
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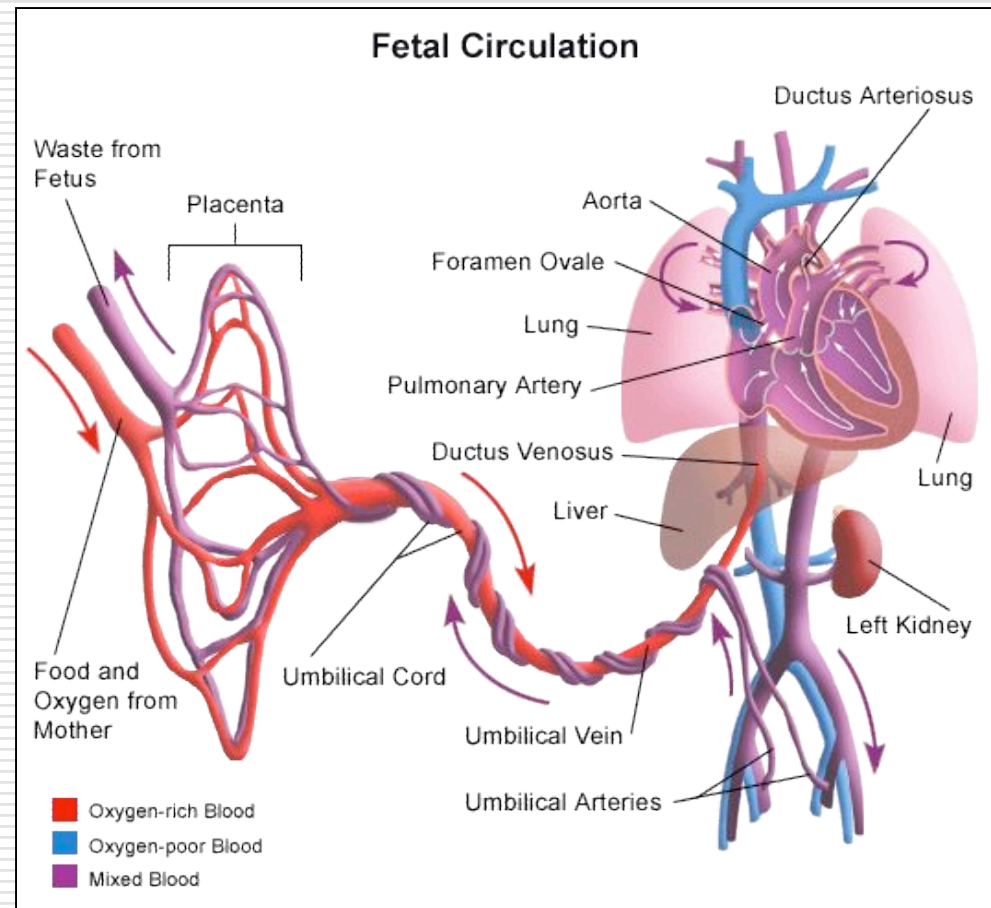
Adult Circulation

- Heart
 - Lungs
 - Arteries
 - Carry blood away from the heart
 - Usually oxygenated
 - Exception: Pulmonary arteries
 - Veins
 - Carry blood towards the heart
 - Ususally deoxygenated
 - Exception: Pulmonary veins
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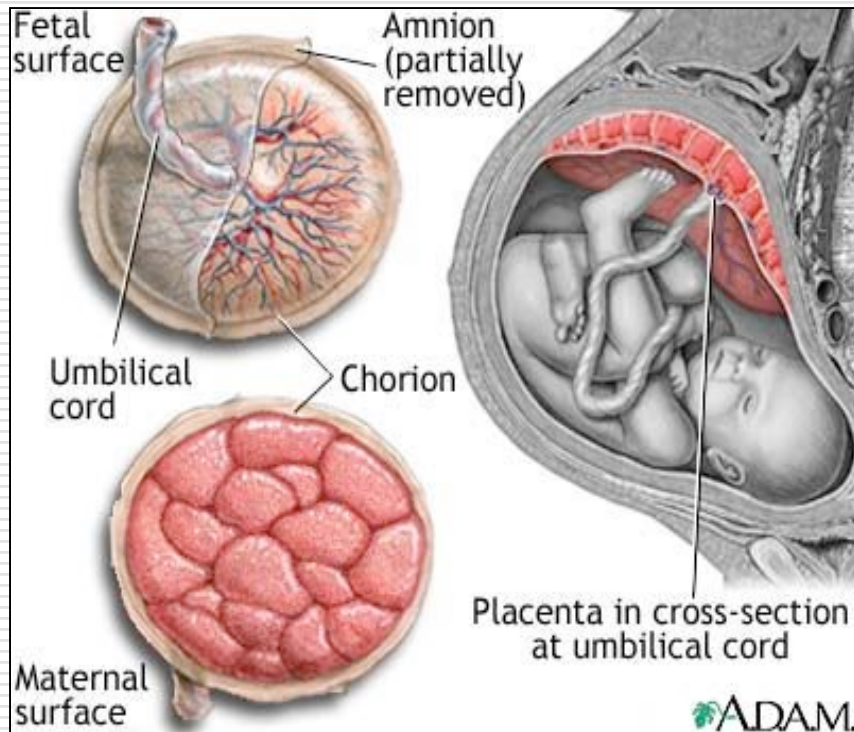


Fetal Circulation

- 2 Umbilical arteries
 - carry deoxygenated blood & waste to the placenta
- 1 Umbilical vein
 - carries oxygenated blood and nutrients from the placenta



The Placenta



- ❑ Facilitates gas, nutrient, and waste exchange between maternal and fetal blood.
- ❑ Maternal and fetal blood do not mix, though certain cells pass (i.e. T-cells).
- ❑ Small molecules (drugs, poisons, etc.) can pass from mother to fetus
 - FAS: Fetal Alcohol Syndrome
 - CO from smoking
 - Meth Amphetamines can lead to brain damage
- ❑ Pharmaceutical Safety
 - (class A, B, C, D, X)

Fetal Hemoglobin (HbF)

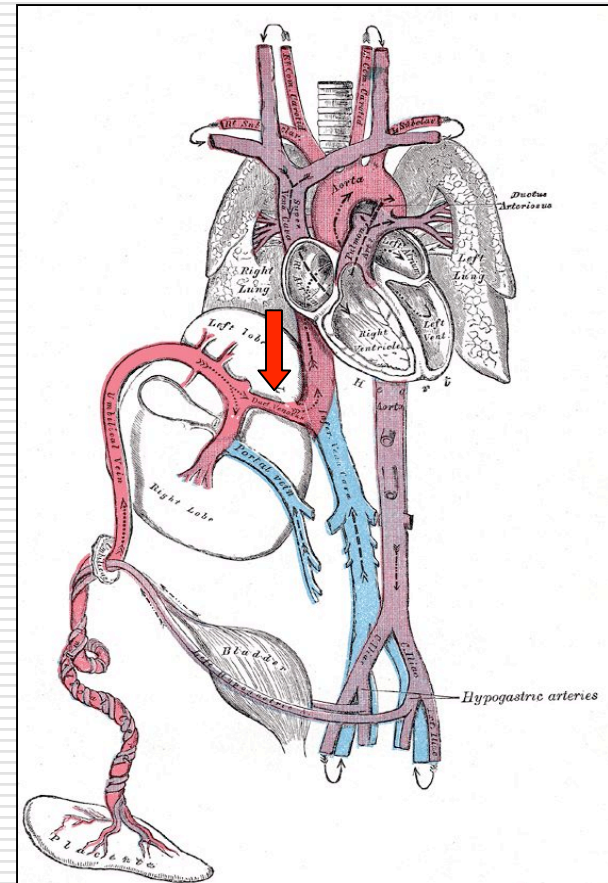
- ❑ Higher O₂ affinity than adult Hemoglobin allows HbF to “suck” oxygen across the placenta into fetal circulation.
 - ❑ After birth, RBCs are killed off and replaced with RBCs containing normal adult Hb.
 - ❑ Rapid death of RBCs in first weeks of life leads to neonatal jaundice
 - Normal up to 1-2 weeks
 - Jaundice after 2 weeks is a problem...
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Cardiovascular Shunts

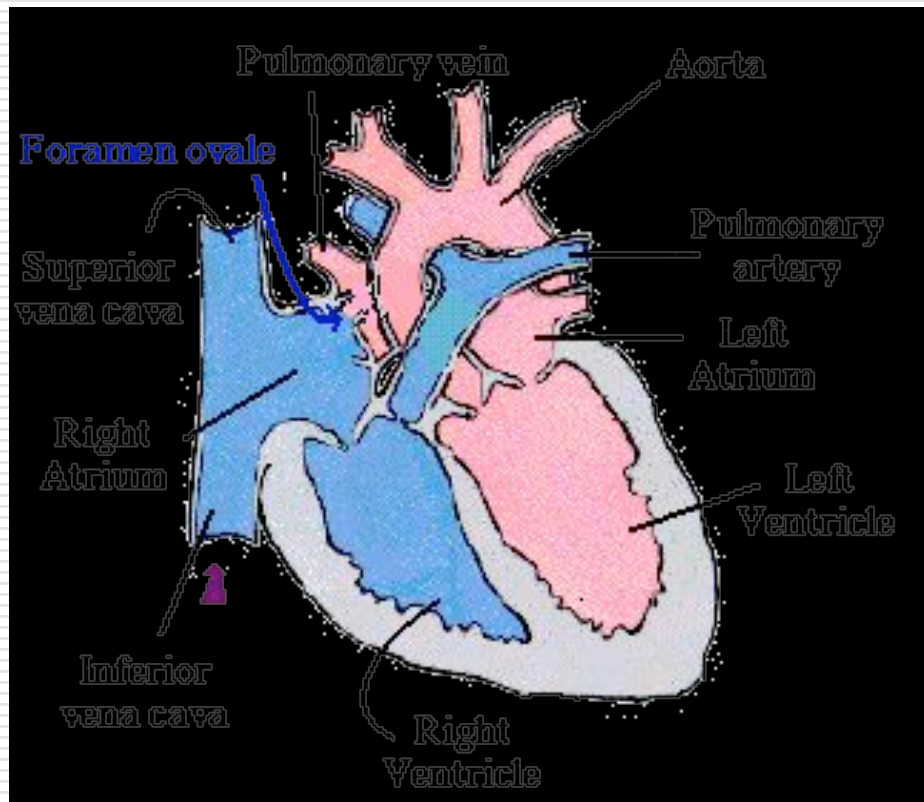
- ❑ Shunt: allows blood to flow from one place to another
 - ❑ Protection of developing organs
 - Blood pressure exerts forces on capillaries
 - Some developing organs can't take the pressure yet
 - ❑ Liver, Lungs
 - ❑ Right \Rightarrow Left shunts protect the lungs
 - In the adult:
 - ❑ Right side of heart holds deoxygenated blood
 - ❑ Blood goes to lungs, gets oxygenated
 - ❑ Oxygenated blood returns to left side of heart
 - With a R \Rightarrow L shunt:
 - ❑ Blood passes from right side of heart to left without passing through the lungs
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Ductus Venosus (Protects Liver)

- ❑ Some blood from the umbilical vein enters the portal circulation allowing the liver to process nutrients.
- ❑ The majority of the blood enters the **ductus venosus**, a shunt which bypasses the liver and puts blood into the hepatic veins.



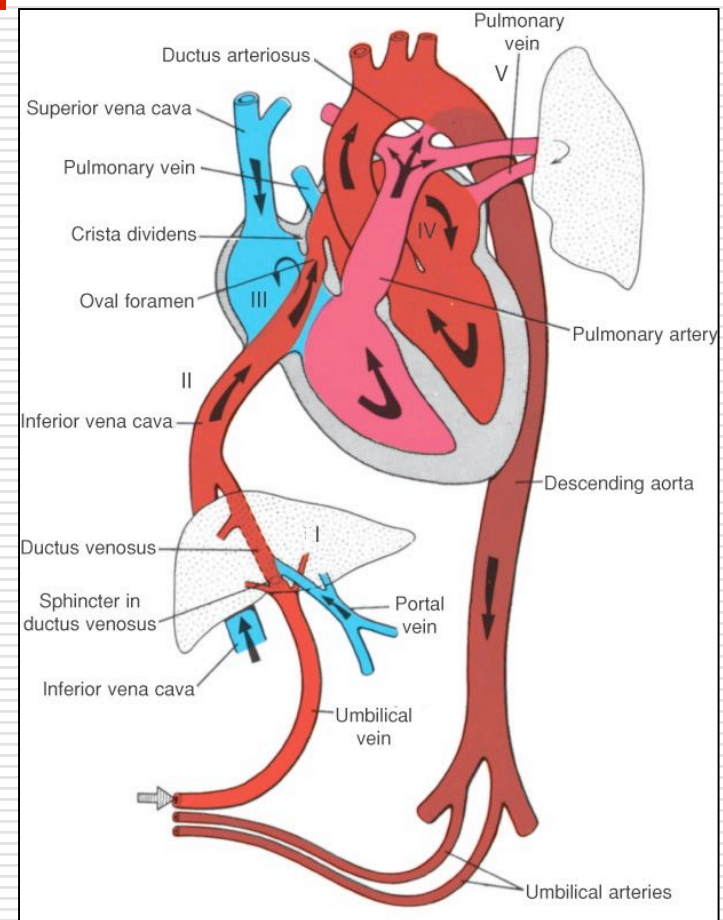
Foramen Ovale (R \Rightarrow L Shunt)



- ❑ Fetal lung capillaries are fragile and can't handle full blood load during development
 - ❑ Some blood is shunted from right atrium to left atrium (foramen ovale) skipping the lungs
 - ❑ More than one-third of blood takes this route
 - ❑ Valve-like flaps prevent back-flow
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Ductus Arteriosus (R \Rightarrow L Shunt)

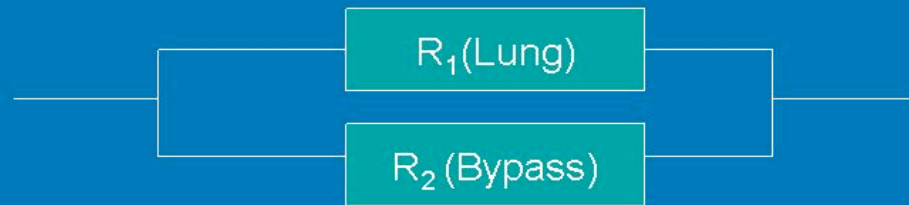
- ❑ Protects the fetal lungs
- ❑ In the adult:
 - Right Ventricle
 - Pulmonary Trunk / Arteries
 - Lungs
 - Pulmonary Veins
 - Left Atrium
 - Aorta
- ❑ In the fetus:
 - Right Ventricle
 - Pulmonary Trunk
 - Most blood goes through DA
 - Aorta



What happens at birth?

- The change from fetal to postnatal circulation happens very quickly.
- Changes are initiated by baby's first breath.

Fetal and Neonatal Circulation



$$1/R_{\text{eq}} = 1/R_1 + 1/R_2$$

Before birth R_1 is high. Thus most of blood bypasses the lung.

After birth R_1 decreases and blood is directed through the lungs.

What happens at birth?

Foramen ovale	Closes shortly after birth, fuses completely in first year.
Ductus arteriosus	Closes soon after birth, becomes ligamentum arteriosum in about 3 months.
Ductus venosus	Ligamentum venosum
Umbilical arteries	Medial umbilical ligaments
Umbilical vein	Ligamentum teres

Pathologic persistence of R \Rightarrow L shunts

- ❑ PFO: Patent Foramen Ovale
 - ❑ PDA: Patent Ductus Arteriosus
 - ❑ Each characterize about 8% of congenital heart defects.
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Pathologic persistence of $R \Rightarrow L$ shunts

□ First problem: Blood Oxygenation

- Any blood that bypasses the lungs fails to be oxygenated
- The larger the $R \Rightarrow L$ shunt, the less the blood gets oxygenated
- Low blood O₂ saturation leads to cyanosis (blue baby)

□ Caveat: Terology of Fallot

- Alfred Blalock, Vivien Thomas
 - Moral: Black guy made it work, white guy got the credit
 - Movie: “Something the Lord Made”
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Pathologic persistence of R \Rightarrow L shunts

- Second Problem: Blood Clots
 - Most blood clots form in veins (lower pressure) and must pass through the heart and lungs before going back to the body
 - Clot caught in the lung: Pulmonary Embolism
 - PFO can allow a clot to bypass the lungs
 - Brain Infarct = Stroke
 - Bowel Infarct = Awful nasty mess
 - Don't be a general surgeon
 - Muscle Infarct = Dr. House
 - Makes you a great doctor but kindof an ass...
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