FETAL CIRCULATION

LEARNING OBJECTIVES

At the end the lecture the student should know the following:

- Components of fetal circulation
- Foramen ovale
- Ductus arteriosus
- Path of Fetal circulation
- Changes in circulation after birth
- Problems with persistence of fetal circulation after birth
- Patent ductus arteriosus and patent foramen ovale

FETAL CIRCULATION

- By the third month of development, all major blood vessels are present and functioning.
- Fetus must have blood flow to placenta.
- Resistance to blood flow is high in lungs.
**UMBILICAL VESSELS**

- Pair of umbilical arteries carry deoxygenated blood & wastes to placenta.
- Umbilical vein carries oxygenated blood and nutrients from the placenta. Located at the navel and enters the liver.

**THE PLACENTA**

- Facilitates gas and nutrient exchange between maternal and fetal blood.
- The blood itself does not mix.

**SHUNTS OF THE FETAL HEART**
- **Foramen ovale**
  Connection between the right and left atria
**Ductus arteriosus**
Connection between the truncus pulmonalis and the aorta

FORAMEN OVALE
- Situated at the lower part of the atrial septum
- Is a valve with two flaps that prevent back-flow.
- Blood is shunted from right atrium to left atrium, skipping the lungs.
- More than one-third of blood takes this route.

**DUCTUS ARTERIOSUS**
- Short tube, about 1.25 cm. in length at birth
- Opens in the aorta, beyond the origin of the left subclavian artery
- The blood pumped from the right ventricle enters the pulmonary trunk.
- Most of this blood is shunted into the aortic arch through the ductus arteriosus.

**UMBILICAL VEIN TO PORTAL CIRCULATION**
- 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.

**FETAL CIRCULATION**

- **Umbilical VEIN** carries oxygenated blood and nutrients from the placenta to the fetus
- ½ of the blood enters the liver, other half into the ductus venous and then into the inferior vena cava
- Oxygenated blood mixes with deoxygenated blood
- Blood flows from inferior vena cava into right atrium

**IN THE RIGHT ATRIUM**

- Blood mixes with the deoxygenated blood from the superior vena cava.
- Blood flows from right into the left atrium through the foramen ovale.
- Again it mixes with a smaller amount of deoxygenated blood from the pulmonary veins.
- After it proceeds to the left ventricle where it is pumped to the heart and brain.
REMAINING BLOOD IN RIGHT ATRIUM

- Remaining blood in the right atrium goes into the right ventricle then to the pulmonary artery.
- Most of the blood bypasses the lungs and goes to the aorta through the ductus arteriosus.
- About 15% of the blood flows through lungs to the right atrium by way of the pulmonary veins.
- How about a guess of the PO2 in the descending aorta?

INTERNAL ILIAC ARTERIES

- Blood from descending aorta goes into common iliac.
- Common iliac arteries branch into the external and internal iliacs.
- The blood in the internal iliacs come into the umbilical arteries and flow back to the placenta to gather oxygen and to get rid of the waste products.

FINALLY THE BIRTH!!!

- All the external sensory stimuli
  - thermal, tactile and visual
- Placenta stops to function
  - Results in a decrease in fetal blood PO2, increase in PCO2 and pH to decrease
- With all these changes what happens…
  - INHALE

AT BIRTH

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

AFTER BIRTH?

- Once the baby is born and the lung, renal, digestive and liver functions are working the fetal circulation undergoes some changes since they are no longer needed

FETAL LUNG FLUID
At birth the lungs are partly inflated with liquid that is equal to the newborns functional residual capacity (FRC)

1/3rd of the fluid is squeezed out of the lungs as the baby passes through the birth canal

1/3rd absorbed by pulmonary capillaries through osmosis.

1/3rd is removed by lymphatic system.

**FIRST BREATH**

A large amount of negative pressure must be generated to overcome the viscous fluid found in the lungs. This pressure is -40cmH20. Up to -100cmH20!

40ml air enters the lungs during the first breath.

When the baby exhales ½ of the amount of air taken in on the first breath is exhaled. The remaining amounts help to create the residual volume.

Average lung compliance is .005L/cmH20 and the airway resistance is 30cmH20/L/sec

**CHANGES IN CIRCULATION**

During the first breath the infant takes, the Pulmonary vascular resistance falls.

Why does this happen?

- A rapid increase in the alveolar PO2 which “offsets” hypoxic vasoconstriction
- Mechanical increase in lung volume. This creates widens the caliber of the extra alveolar vessels

**AS THE PVR DECREASES…..**

More blood flows through the lungs which allows for more blood to come to the left atrium. The results in a increase pressure in the left atrium which allows the flap of the foramen ovale to close. The closure is also helped by the fall in pressure in the right atrium as the umbilical flow stops.

Next…smooth muscles in the ductusarteriosus constrict due to the increase in PO2.

**EFFECTS OF INCREASED PO2**
• The PO2 in a newborn must rise higher than 45-50mmHg to allow the ductus arteriosus to close. If it is not reached the ductus will not close and the PVR will remain elevated causing Persistent Pulmonary Hypertension of the Newborn (PPHN)
• If the PO2 initially rises to the desired level but then falls in the first 24-48 hours after birth the ductus will re-open

**VITAL SIGNS OF THE NEWBORN**

- Respiration Rate (RR) 35-50/min
- Heart Rate (HR) 130-150/min
- Blood Pressure (BP) 60/40-70/45

**PERSISTENCE OF FETAL CIRCULATION:**

- **Patent (open) ductus arteriosus** and **patent foramen ovale** each characterize about 8% of congenital heart defects.
- Both cause a mixing of oxygen-rich and oxygen-poor blood; blood reaching tissues not fully oxygenated. Can cause cyanosis.
- Surgical correction now available, ideally completed around age two.
- Many of these defects go undetected until child is at least school age.

**TREATMENT**

- Surgical Closure
- Indomethacin (prostaglandin synthetase inhibitor)