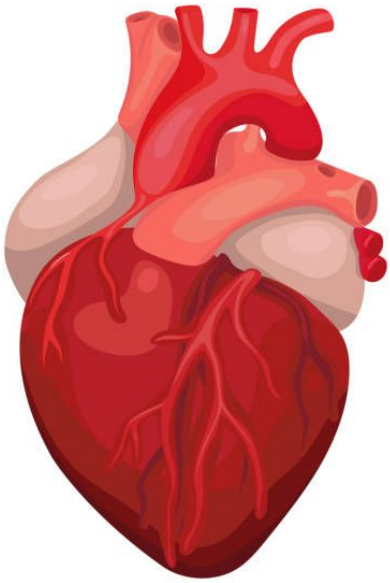
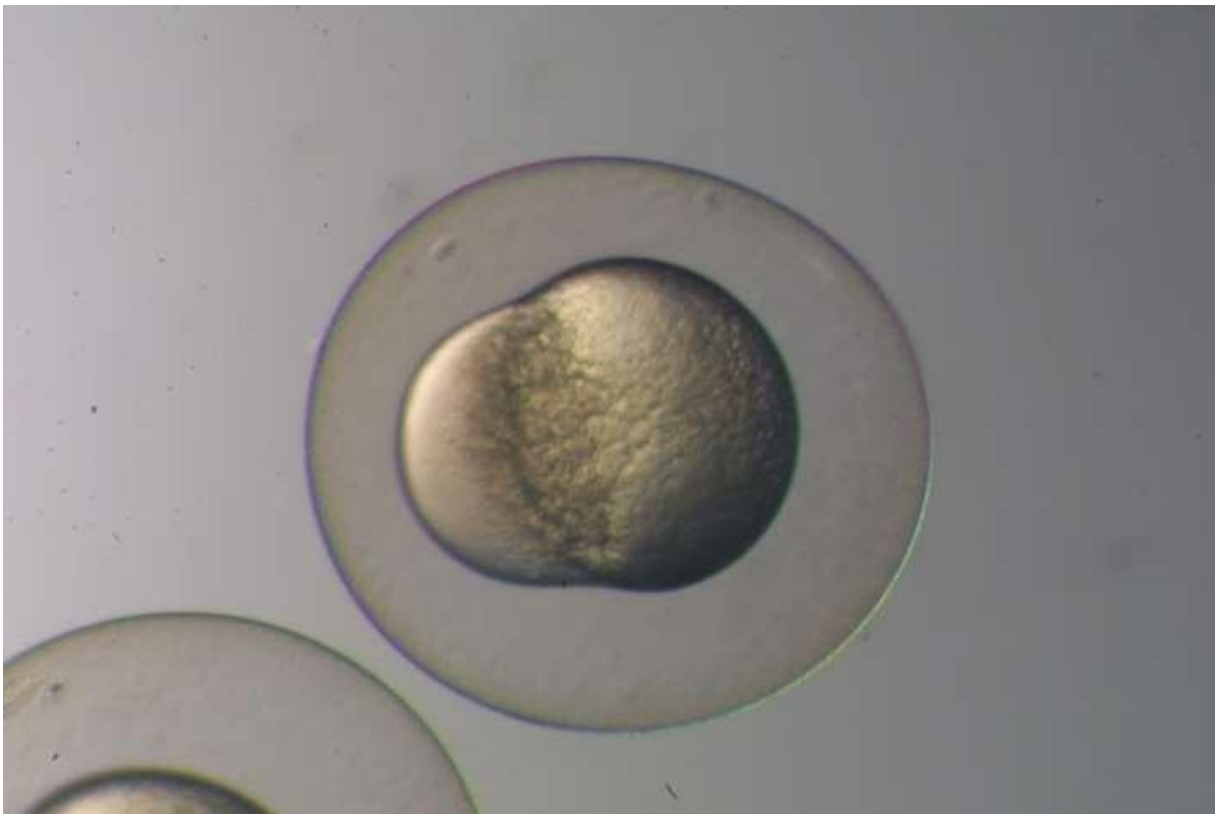
Embryology of the CVS

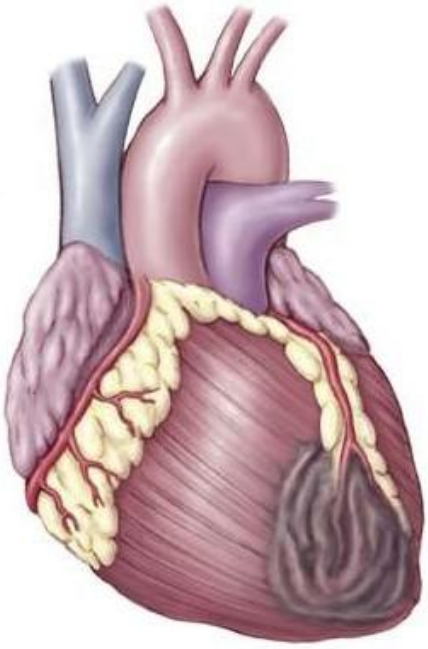


DR SHAHAB
Associate Professor Anatomy
KGMC

Getting from this

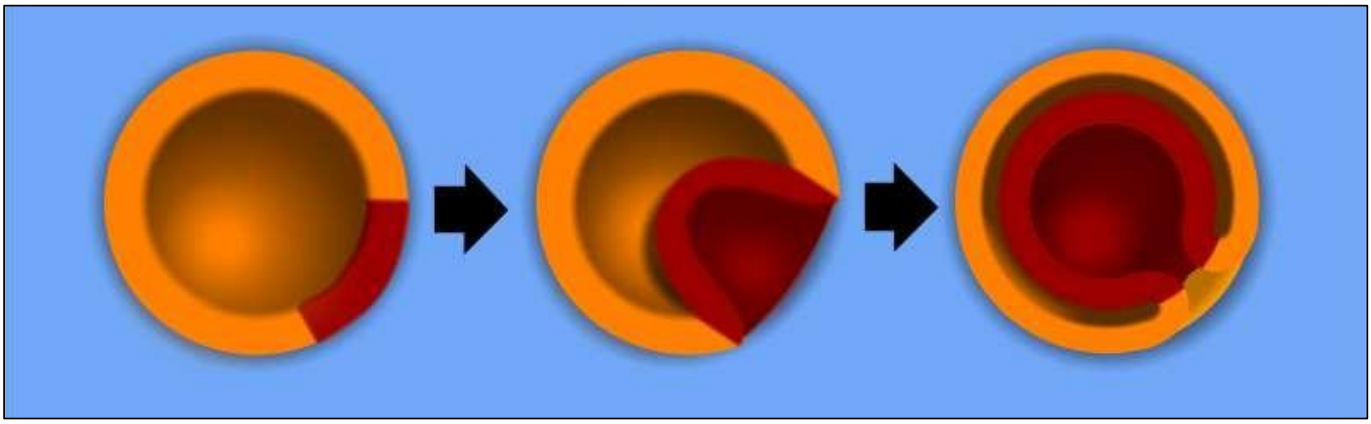


To this



Gastrulation

- Mass Movement and invagination of the blastula (ball of cells) to form three layers
  - Ectoderm
  - Mesoderm
  - Endoderm



Each layer forms:

- Ectoderm
  - Skin, nervous system, neural crest (coronary arteries and cardiac outflow)
- Mesoderm
  - All muscle types, most systems (including CV), blood and kidneys
- Endoderm
  - GI Tract (liver and pancreas) endocrine organs

Cardiovascular Embryology

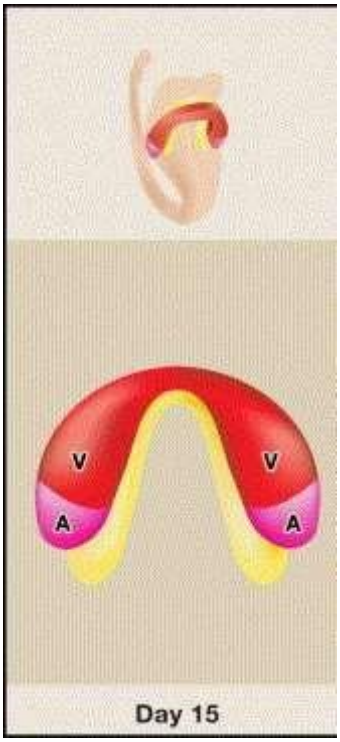
- Mesoderm
  - Smooth muscle, blood, heart, endothelium
- Ectoderm
  - Neural crest cells

- Question: When does it start?

Day 15

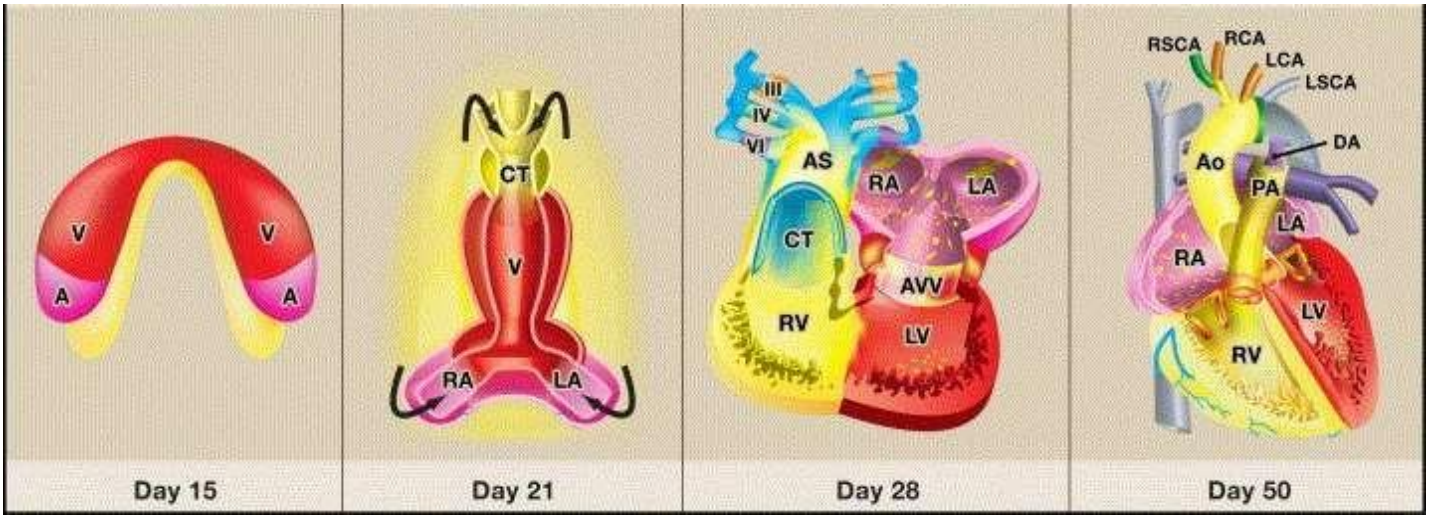
- First heart field is RED
- The Second heart field is YELLOW

- The first HF will become the left ventricle
- The second will become the outflow tract, future right ventricle and atria



Over time…

- Day 21 – Tube
- Day 28 – 4 Chambers
- Day 50 – Fully functioning



3 stages of cardiac formation

1. Formation of the primitive heart tube

2. Cardiac looping

3. Cardiac Septation

3 stages of cardiac formation

1. Formation of the primitive heart tube

2. Cardiac looping

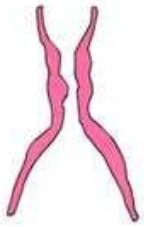
3. Cardiac Septation

Forming the heart tube

- 3rd week of development the heart is formed from the cardiogenic region (look like a horse shoe)

Day 19

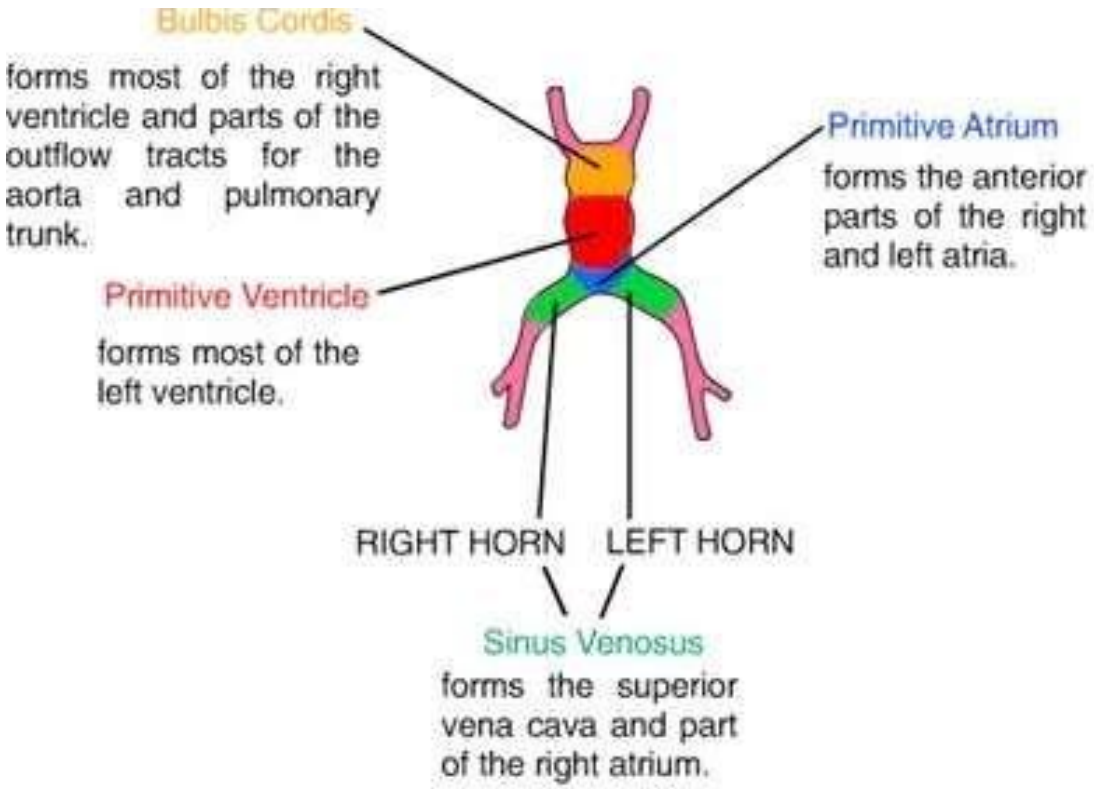
- 2 endocardial tubes form



- They then fuse to form a single primitive heart tube (GATA)

Endocardial tube

- Becomes surrounded by myocardium and the visceral layer of the serious pericardium
- Cephalic end = Arterial end
- Causal end = Venous end
- Arterial end is beyond the pericardium with a large vessel – Aortic sac
- Heart beats at day 22
- Nkx2.5 increases heart size


Bulbis Cordis
forms most of the right ventricle and parts of the outflow tracts for the aorta and pulmonary trunk.
Primitive Atrium
forms the anterior parts of the right and left atria.
Primitive Ventricle
forms most of the left ventricle.
RIGHT HORN
LEFT HORN
Sinus Venosus
forms the superior vena cava and part of the right atrium.

Cardiac Looping – Day 23

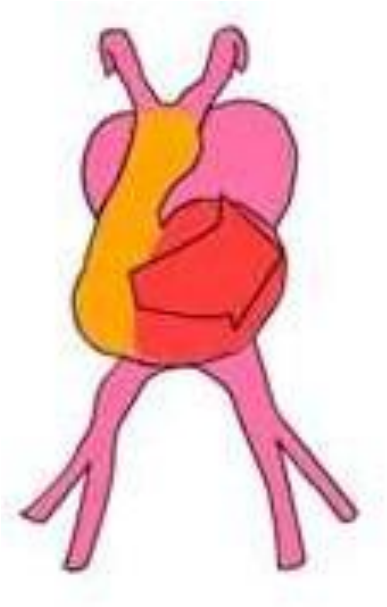
- Bulbis Cordis moves inferiorly, anteriorly and to the embryos right

- (like down, in front and right)
- ORANGE Cha Cha slide

Continued

- The primitive ventricle moves to the embryos left side

- (RED Box to the left)



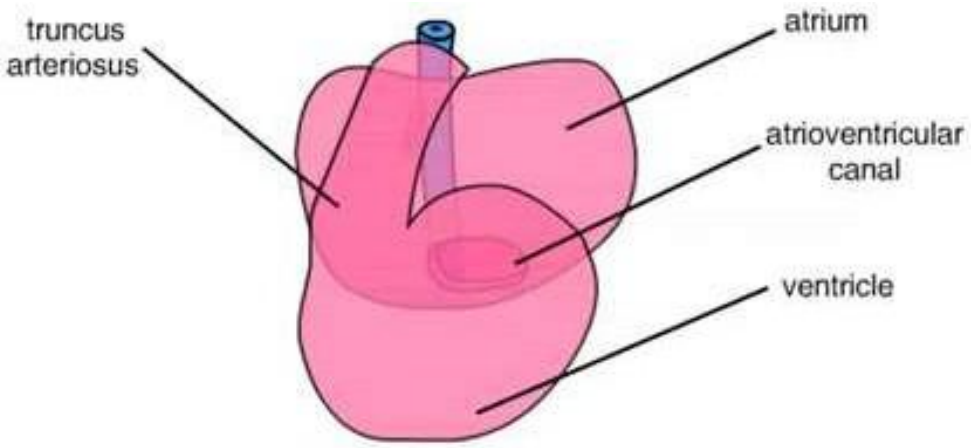
Continued

- Primitive atrium and sinus venousus move superiorly and posterior

- (Green and blue Love lifts us up where we belong)
- The sinus venousus is posterior to the primative atrium

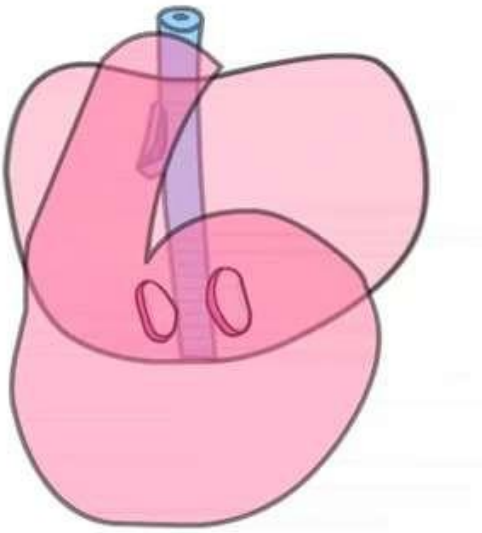
Atrioventricular canal

- There is only one common atrium and one ventricle at the moment
- Connected by atrioventricular canal

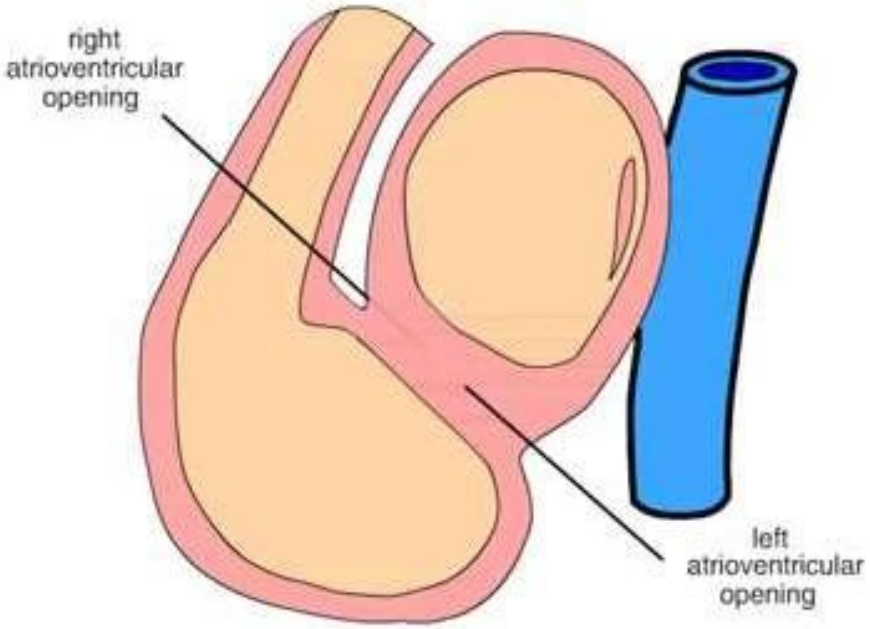


Endocardial cushions!

- There are two, the superior (on top) and the inferior (bottom)
- They grow together whilst the canal is repositioning itself to the right heart
- They fuse to form two separate openings, left and right canals.



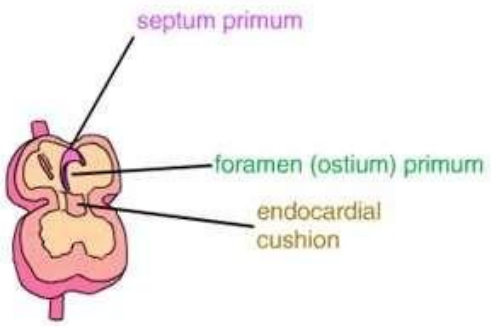
Side view



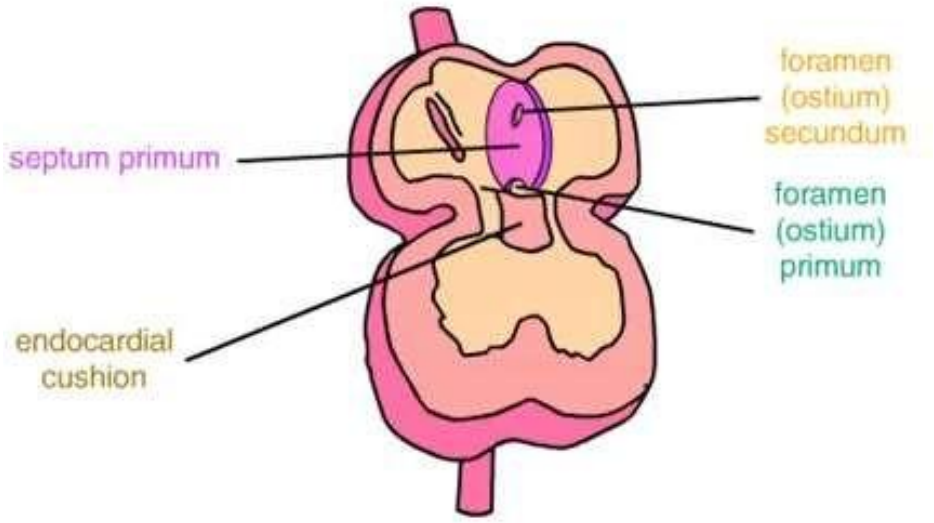
These canals will become the left and right atrioventricular openings of the heart.

Cardiac Septation

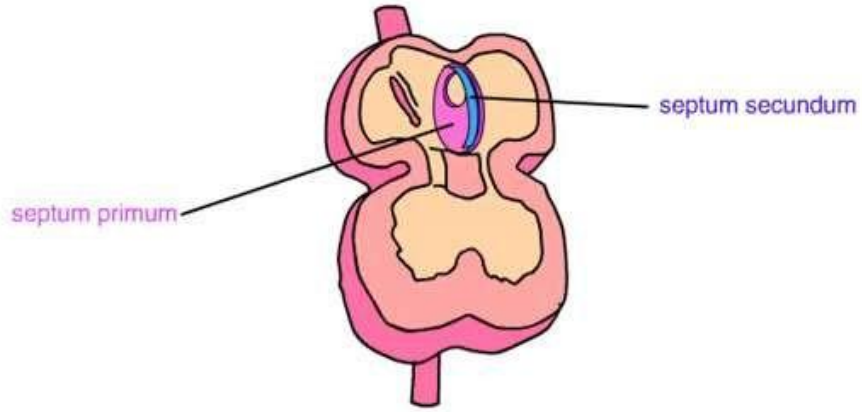
- Week 4 (this is going on at the same time as the growth etc)
- Septum primum (crescent-shaped tissue) grows towards the endocardial tissues
- The opening between the septum primum and the endocardial cushion foramen primum. Shunting



- Just before the septum primum closes it forms another hole (foramen secundum) to allow shunting.

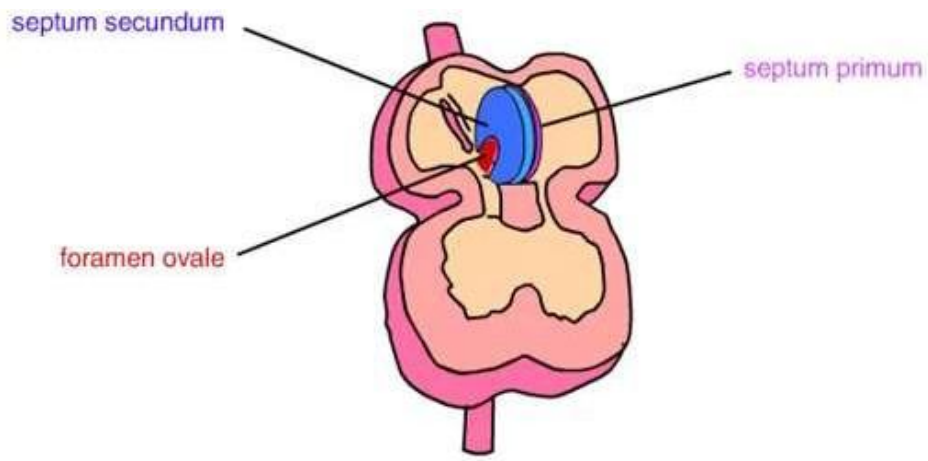


- The second bit of tissue grows towards the endocardial cushions = Septum secundum
- Thick muscular compared to thin first one

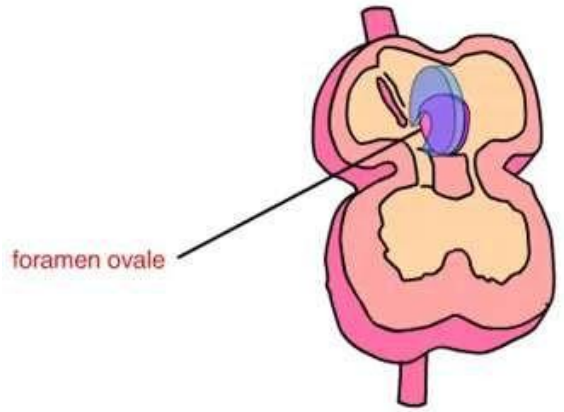


End of week 6

- Septum secundum finishes growing
- Permanent opening on posterior-inferior surface
- Foramen Ovale

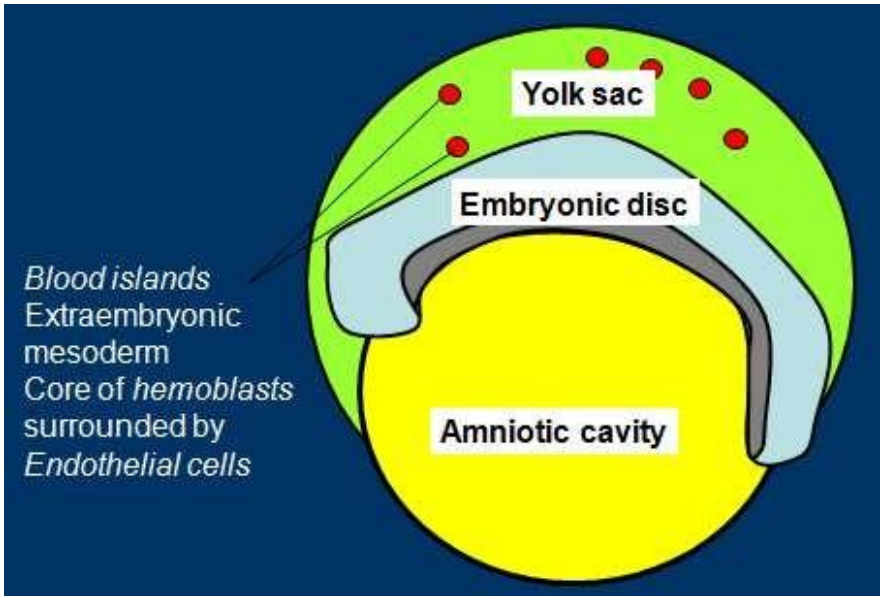


- The septum primum gradually degenerates
- The lower part remains as the valve of the foramen ovale
- It closes when baby is born
- Fossa ovalis



Embryology of Circulation

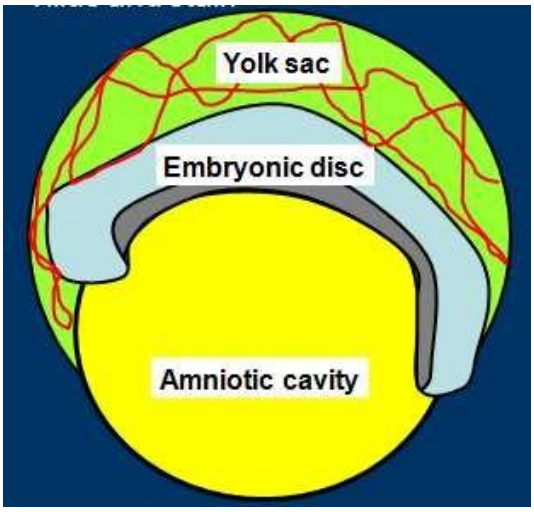
Formation of blood islands



“aggregations of mesenchymal cells in the angioblast of the early embryo, developing into vascular endothelium and blood cells.”

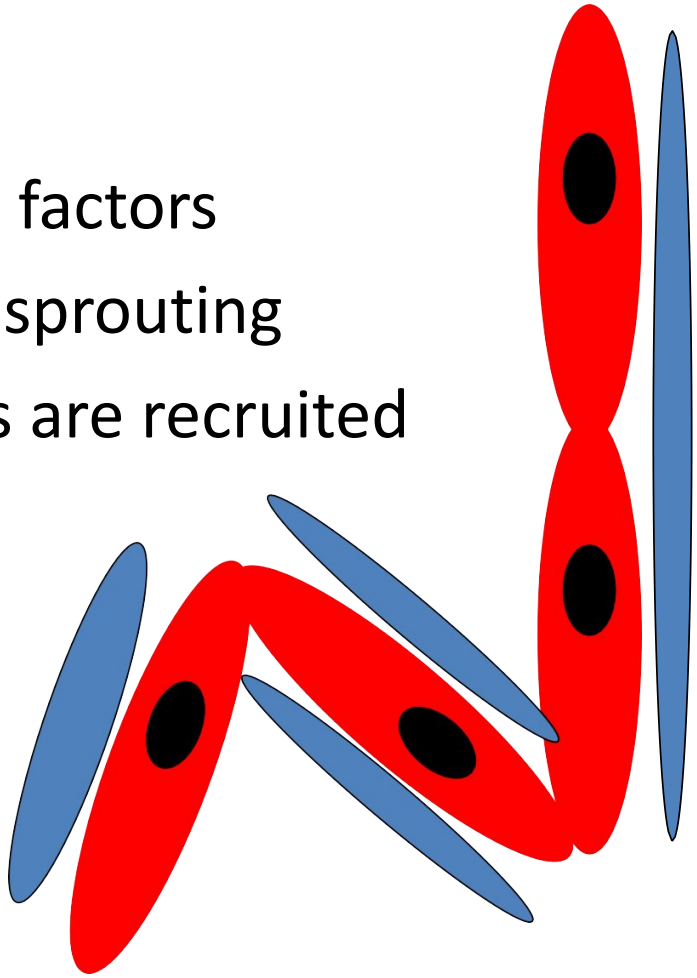
Vascularisation

- Day 17-21
- Vascularisation of yolk sac, chorionic villus (absorbs oxygen) and stalk
- Angioblasts from mesoderm join together to form angioblastic cords through the embryonic disc

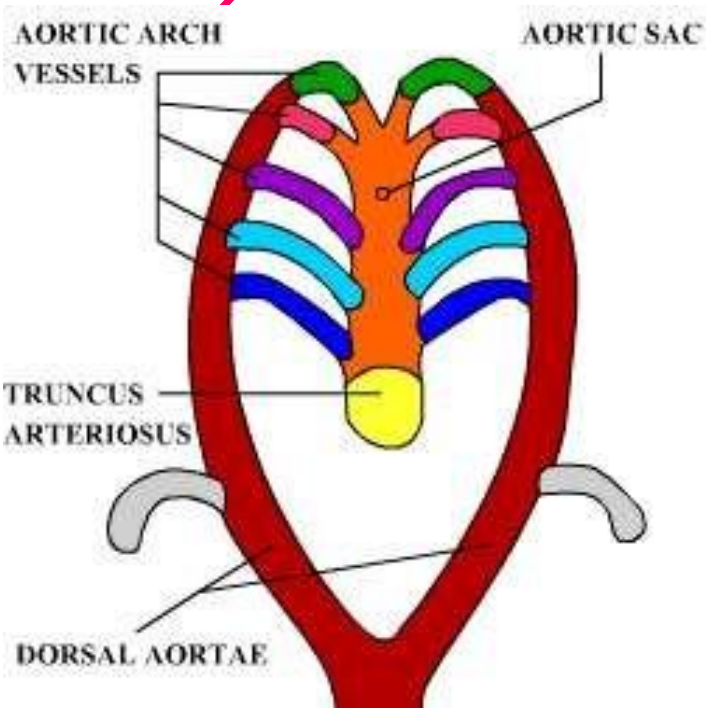


Vasculogenesis/Angiogenesis

- Day 18 onwards
- Driven by growth factors
- Proliferation and sprouting
- Mesodermal cells are recruited



Aortic arches: 1st and 2nd

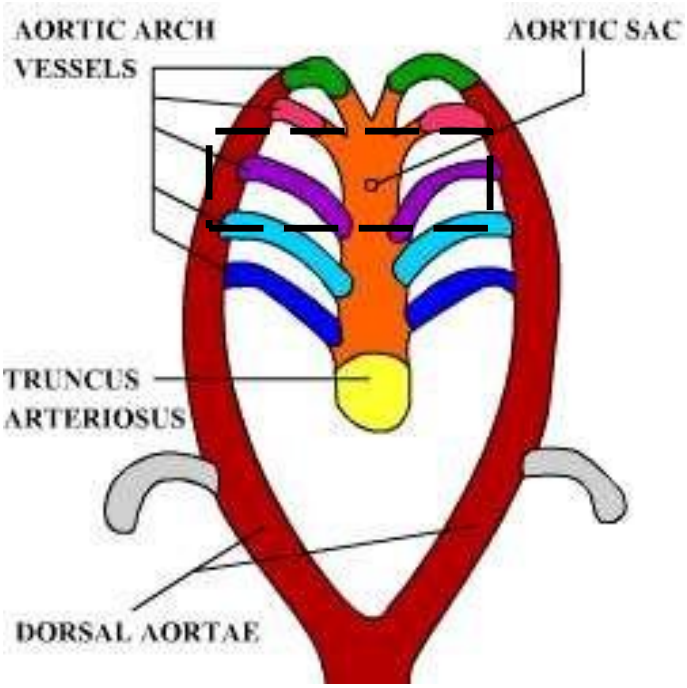


Become minor head vessels

1st – small part of maxillary

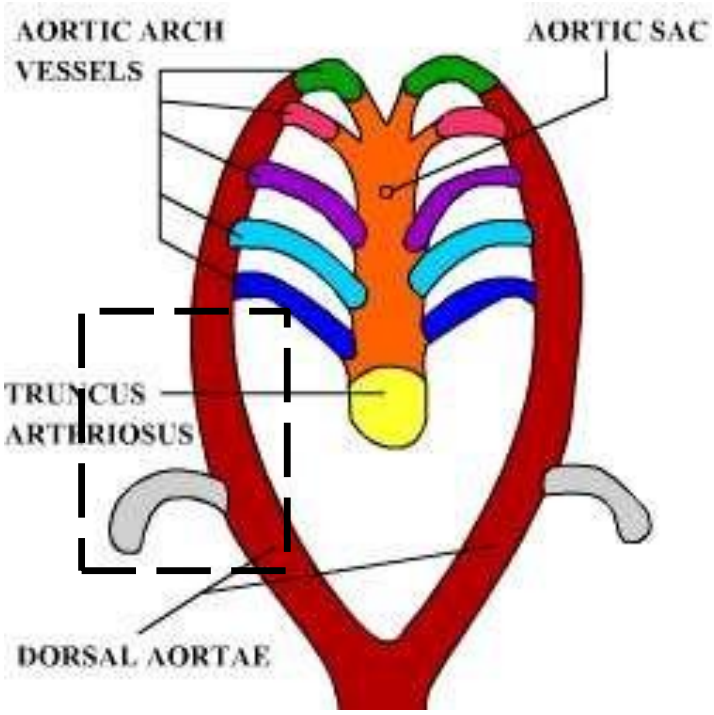
2nd - artery to stapedius

3rd Aortic arch



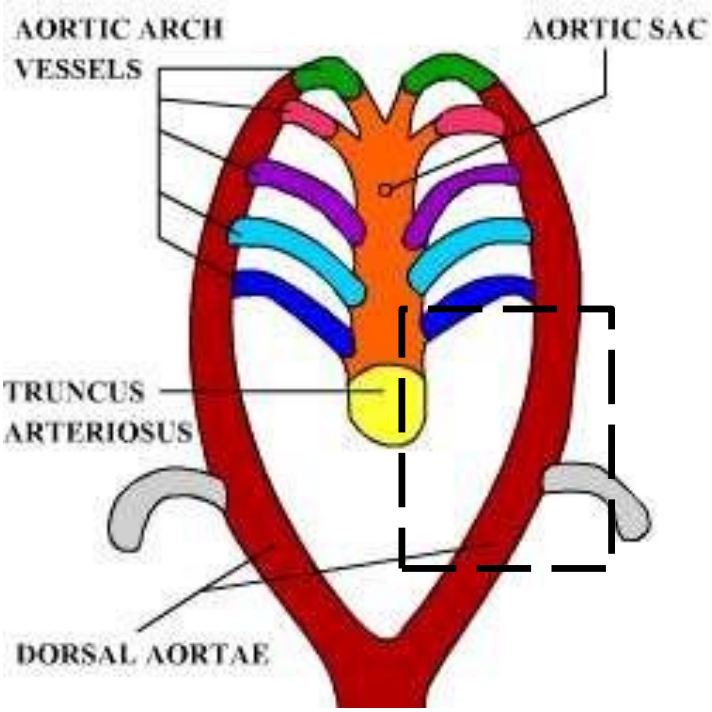
- Become common carotid arteries, and proximal internal carotid arteries
- Distal internal carotids come from extension of dorsal aortae

Right dorsal Aortae and Right 4th



- R dorsal aorta looses connections with midline aorta and 6th arch, remaining connected to R 4th arch
- Acquires branch 7th cervical intersegmental artery, which grows into R upper limb
- Right subclavian artery is derived from right 4th arch, right dorsal aorta, and right 7th intersegmental artery

Left dorsal Aortae and left 4th

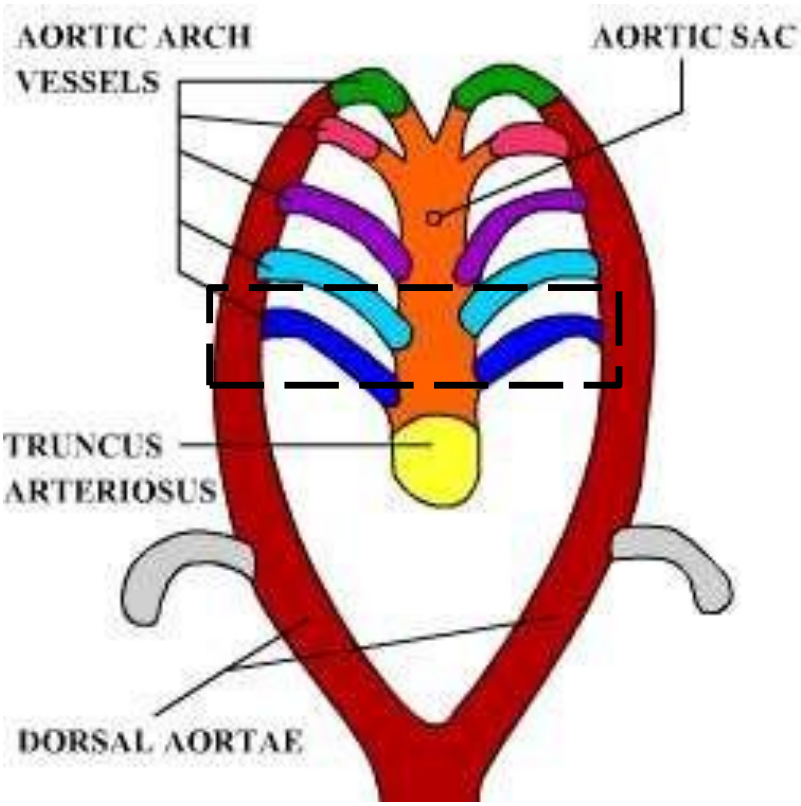


- Left dorsal aorta continues into trunk
- Left 7th cervical intersegmental artery, which grows into left subclavian artery
- Right subclavian artery is derived from right 4th arch, right dorsal aorta, and right 7th intersegmental artery

5th arches

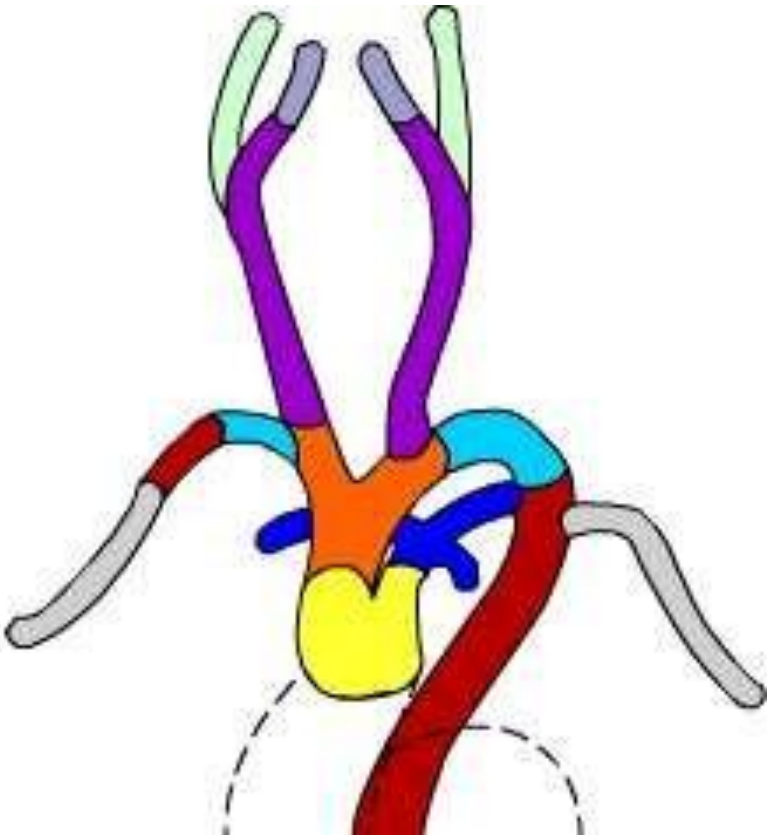
There are none. HA

6th arches



- Right arch may form part of pulmonary trunk
- Left arch forms ductus arteriosus – communication between pulmonary artery and aorta

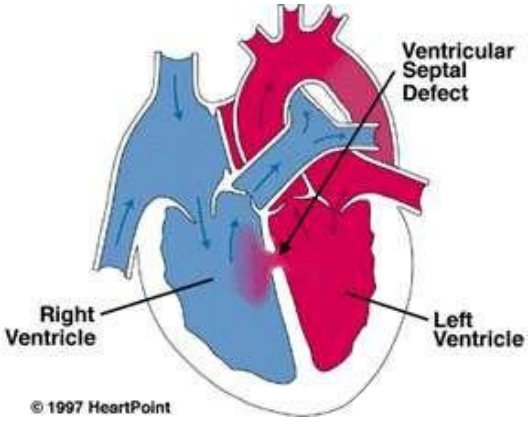
This is what it looks like:



Congenital abnormalities

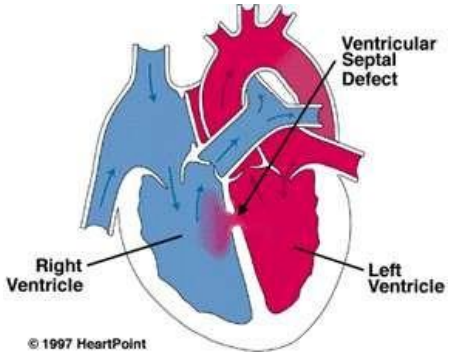
Ventricular Septal Defect

- Abnormal connection between the two ventricles
- 20% of all heart defects
- Many close on their own in childhood



VSD

- High pressure in the left ventricle
- Low pressure in the right ventricle
- Blood flows from high to low
- Some oxygenated blood gets into RV
- Increased blood flow to the lungs



VSD- Size of holes

- Large
- High pulmonary flow in infancy
- Breathlessness
- Poor feeding
- Need it fixed (PA band/ repair)
- Eisenmenger’s Syndrome

- Small
- Small increase in pulmonary flow
- Risk of endocarditis
- No intervention needed

Clinical signs

- Large
- Small skinny breathless
- Increased resp. rate
- Tachycardia
- Big heart
- Murmur varies

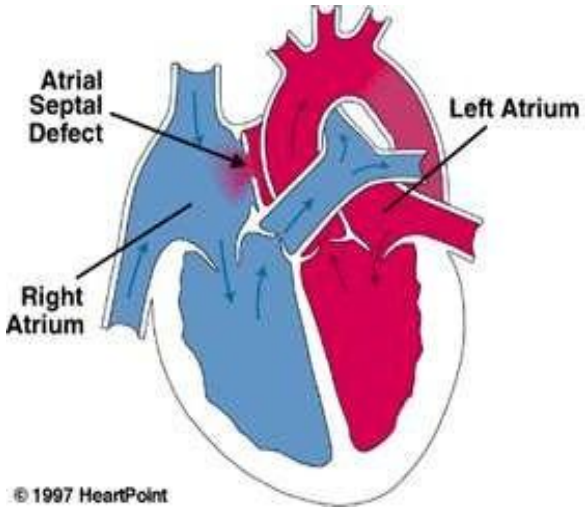
- Small
- Loud systolic murmur
- Thrill (buzzing)
- Well grown
- Normal heart rate and size

Eisenmenger's syndrome

- High pressure pulmonary blood flow
- Damage to pulmonary vasculature
- Resistance in lungs increase
- Right ventricle pressure increases
- Blood flow reverses
- Shunt
- BLUE

Atrial Septal Defects(ASD)

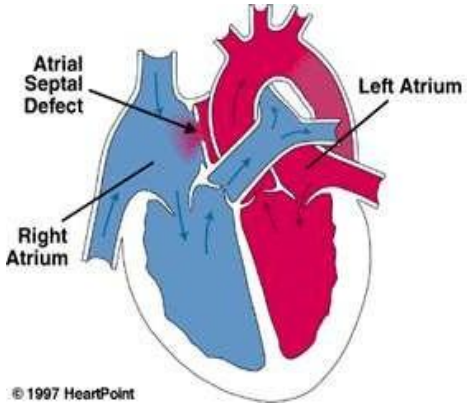
- Abnormal connection between two atria
- Septum primum/secundum or sinus venousus
- Common
- Present in adulthood mostly
- Slightly higher pressure in the left atrium than the right atrium
- Left to right shunt
- NOT BLUE



ASD- Size of holes

- Large
- Increased flow to the right heart and lungs
- Right heart dilation
- Increased chest infections
- SOBOE
- Should be closed if its stretching the heart

- Small
- Small increase in flow
- No right heart dilation
- No symptoms
- Leave it alone!



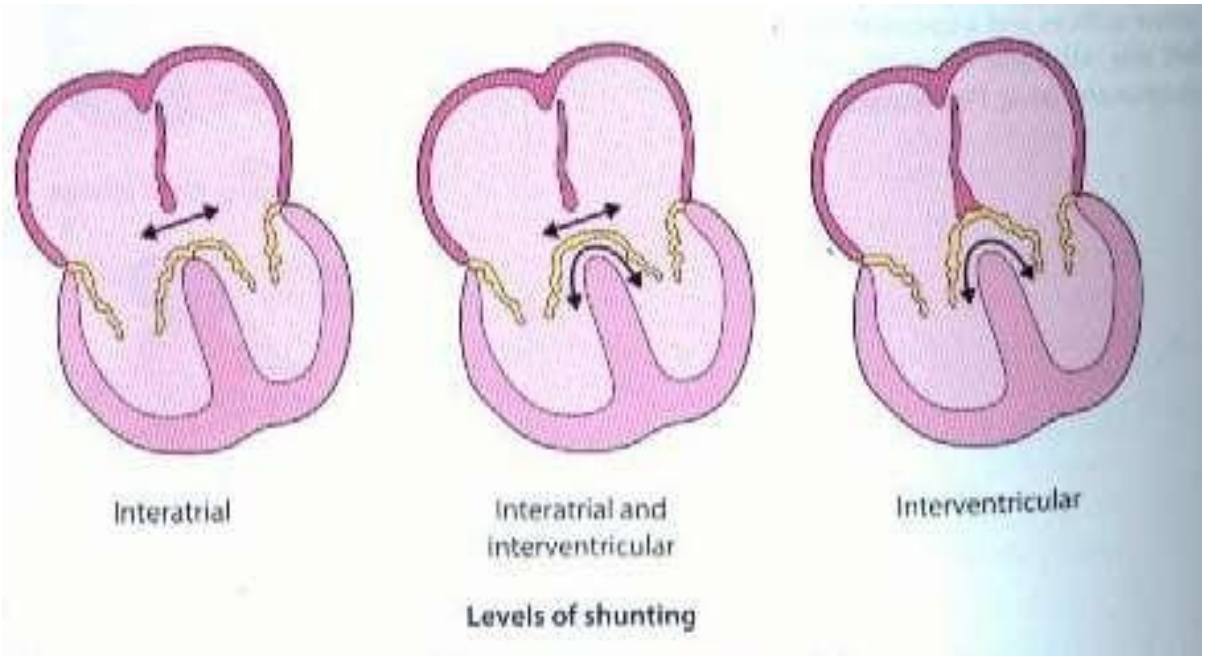
Clinical signs of ASD's

- Pulmonary flow murmur
- Fixed split second heart sound (delayed closure of pulmonary valve)
- BIG pulmonary arties on X ray
- BIG heart
- Close:
  - Surgical
  - Percutaneous (umbrella)

Atrioventricular Septal Defects

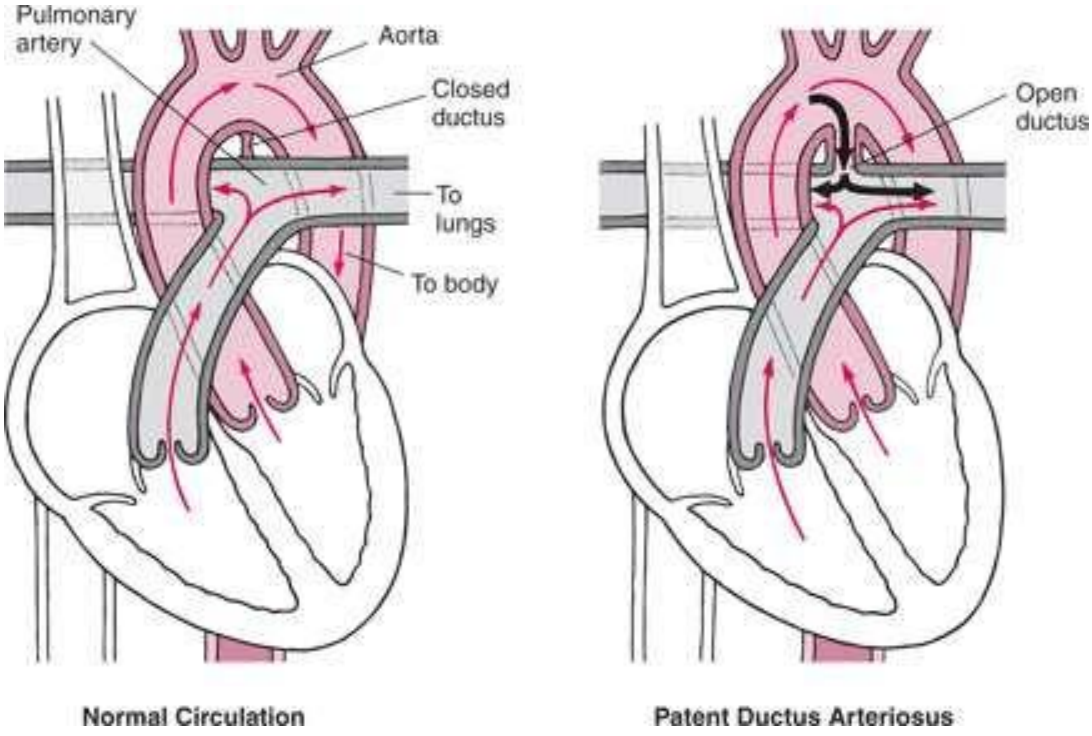
- 2 in 10000 live births (common in downs)
- Hole at very centre of heart
- Involves Atrial septum, ventricular septum, mitral and tricuspid valves
- Complete or partial
- Just one massive malformed valve
- Leaky

AVSD


Interatrial
Interatrial and interventricular
Interventricular
Levels of shunting

Patent Ductus Arteriosus

- Aortic arch joined to the pulmonary artery



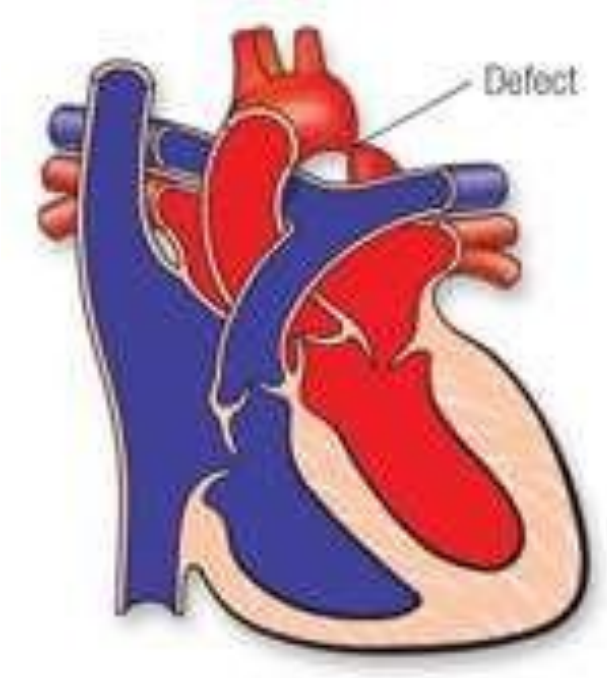
Clinical Signs and Treatment

- Signs
- Continuous machinery murmur
- Big heart and breathless
- Eisenmenger's syndrome
- Blue
- Clubbing

- Treatments
- Surgical or Percutaneous
- Local anaesthetics
- Venous approach (AV loop)
- Low risk operation

Coarctation of the Aorta

- Narrowing of the aorta at the side of insertion of the Ductus Arteriosus



Bicuspid Atrioventricular Valves

- Normally they have 3
- This time there's only 2
- Severely stenotic
- Degenerate quicker
- Regurgitate earlier

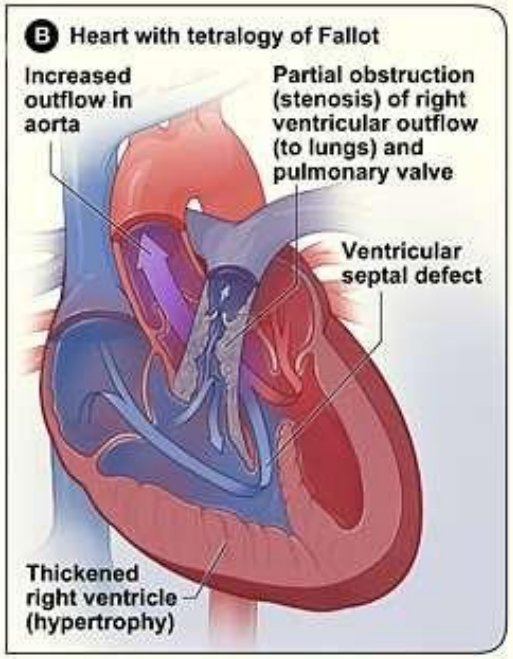
Bicuspid Aortic Valve with thickened leaflets

- Association with coarctation and dilation of ascending aorta

Tetralogy of Fallot

1. Ventricular Septal Defect
2. Pulmonary Stenosis
3. Hypertrophy of Right Ventricle
4. Overriding Aorta
   - Shunt from RV to LV
   - Blue

Cause 10% of all heart defects



Clinical Signs and Repair

- Signs
- Cyanosed
- Clubbed
- Harsh Systolic murmur from the right ventricle outflow tract obstruction (RVOT)

- Repair
- By the age of 2
- Close the VSD
- Resect the RVOT obstruction
- They may get pulmonary valve obstruction in adult life

https://youtu.be/-d2UfOePgZw

https://youtu.be/-d2UfOePgZw


Thank
you