

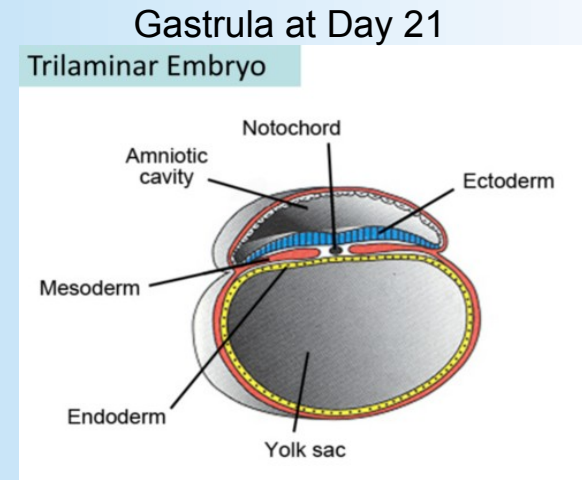
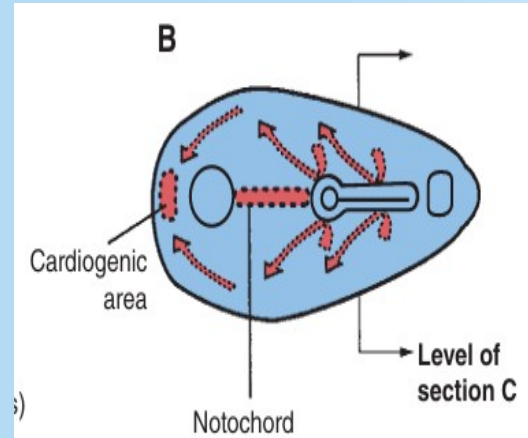
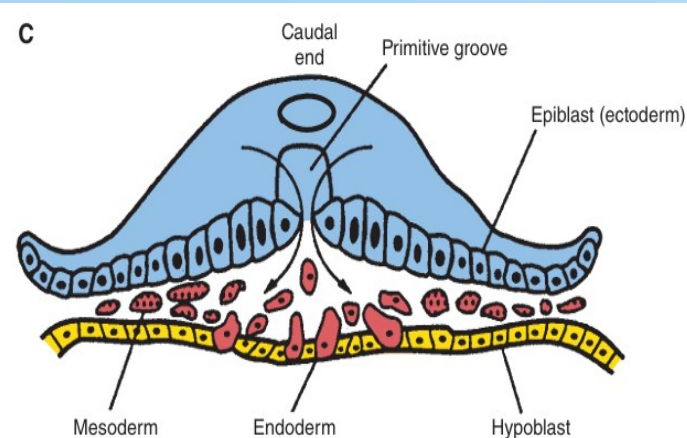
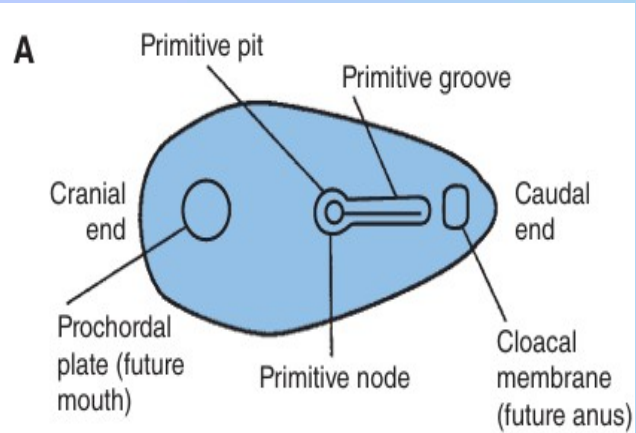
Heart Embryology and Anatomy

By Thomas Dlugosz

Brief Recall of Gastrulation

The process of gastrulation establishes 3 germ layers of the embryo: **ectoderm**, **mesoderm** and **endoderm**.

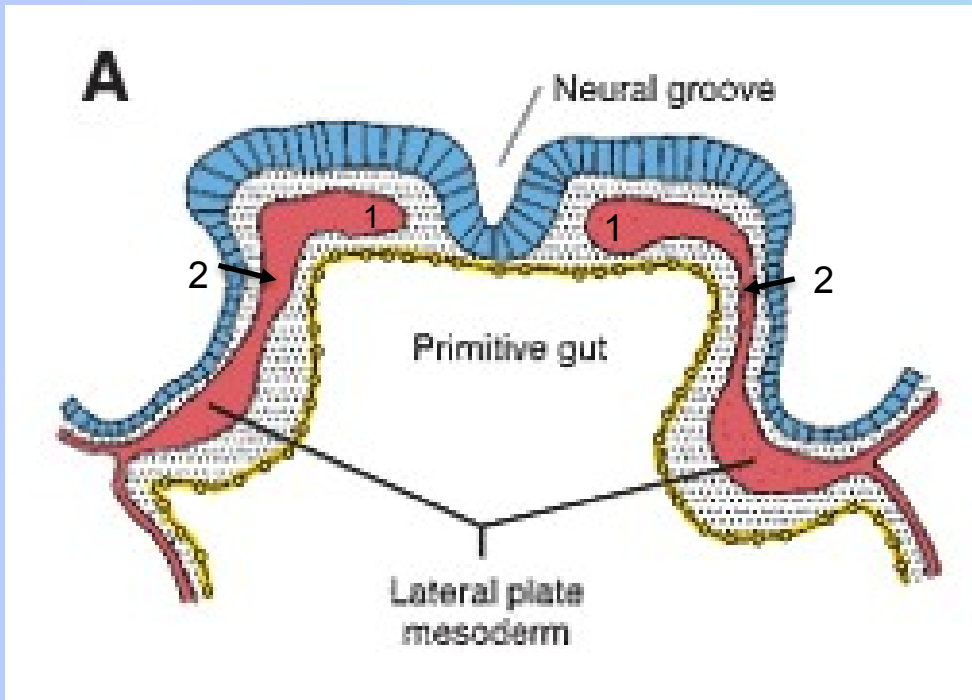
It forms a trilaminar embryonic disk by day 21 of development.



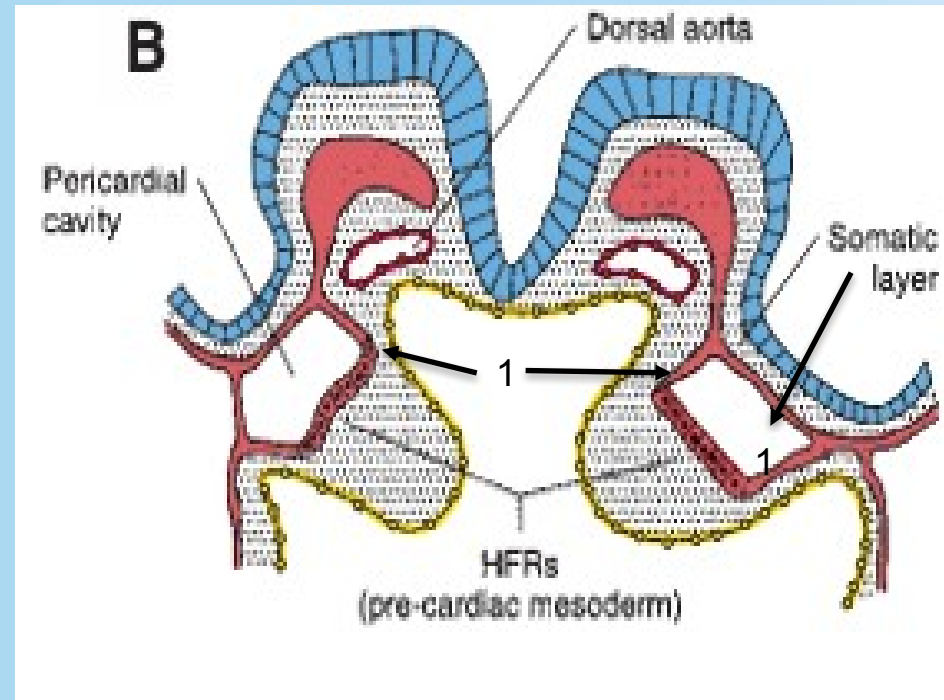
The first wave of epiblasts that migrate through the primitive groove displace hypoblasts to begin formation of the **endoderm**. Next, epiblasts begin to form mesoderm. Remaining epiblasts mature into the **ectoderm**

Cardiogenic area contains mesoderm that will be the future heart!

Heart Embryology

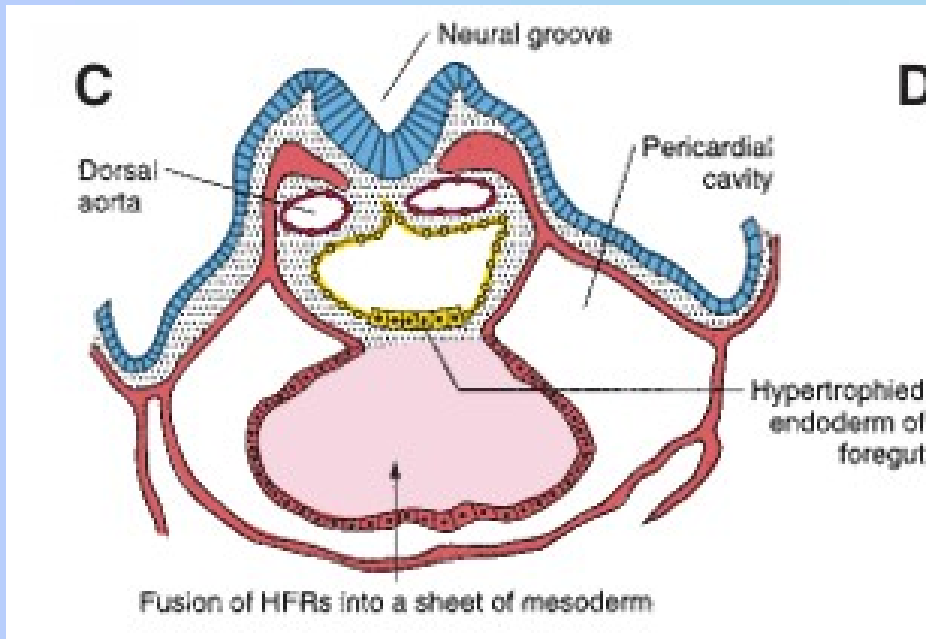


Cross section of gastrula in 3rd week at cardiogenic region. (1) Paraxial mesoderm. (2) intermediate mesoderm. Yellow cells are endoderm. Blue cells are ectoderm.

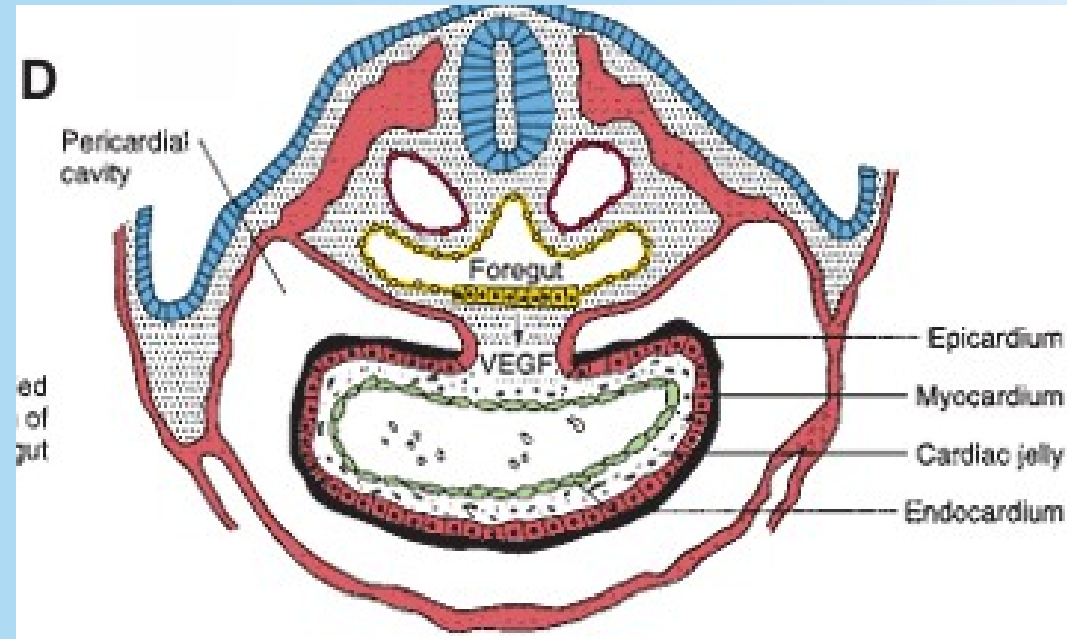


Lateral plate mesoderm then splits into somatic and splanchnic layers (1). Precardiac mesoderm moves into the splanchnic layer and differentiates into heart forming regions (HFRs). Lateral folding occurs as shown.

Heart Embryology

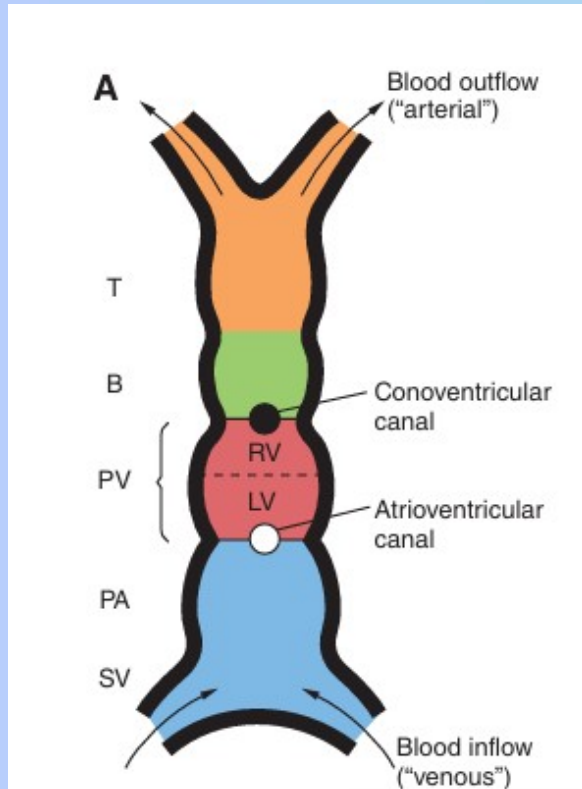


After lateral folding, HFRs fuse to form a mesoderm sheet. Endoderm is sealed off by lateral folding and is contained within the precardiac mesoderm



VEGF from hypertrophied endoderm causes the sheet of mesoderm to form discontinuous vascular channels that remodel into an **endocardial tube (endocardium)**. Mesoderm overlying the endocardium forms **myocardium**. This secretes matrix proteins called **cardiac jelly**. Lastly more mesoderm then forms the **epicardium**. The **primitive heart tube** is now formed

Cardiac Tube



Embryonic Dilation	Adult Structure
Truncus arteriosus (T)	Aorta Pulmonary trunk
Bulbus cordis (B)	Smooth part of right ventricle (conus arteriosus) Smooth part of left ventricle (aortic vestibule)
Primitive ventricle (PV)	Trabeculated part of right ventricle (RV) Trabeculated part of left ventricle (LV)
Primitive atrium (PA)	Trabeculated part of right atrium Trabeculated part of left atrium
Sinus venosus (SV)	Smooth part of right atrium (sinus venarum) ^a Coronary sinus Oblique vein of left atrium

Mnemonics

TAP

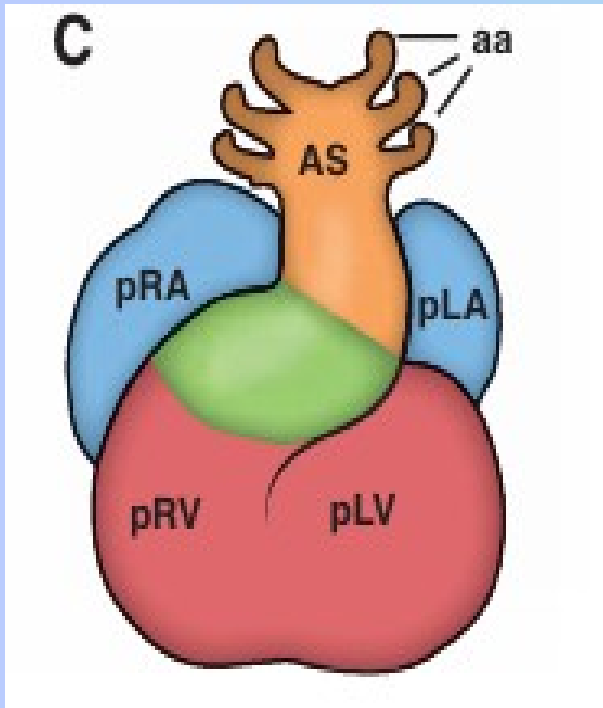
Light **Bulbs** are **Very Smooth**

PV TV

PA TA

Sinus venosum = Sinus venarum, coronary sinus and oblique vein of left atrium

Aortic Arches



Legend:

B- Bulbus cordis

PV- Primitive Ventricle

PA-Primitive Atria

SV- Sinus Venosus

AS- Aortic Sac

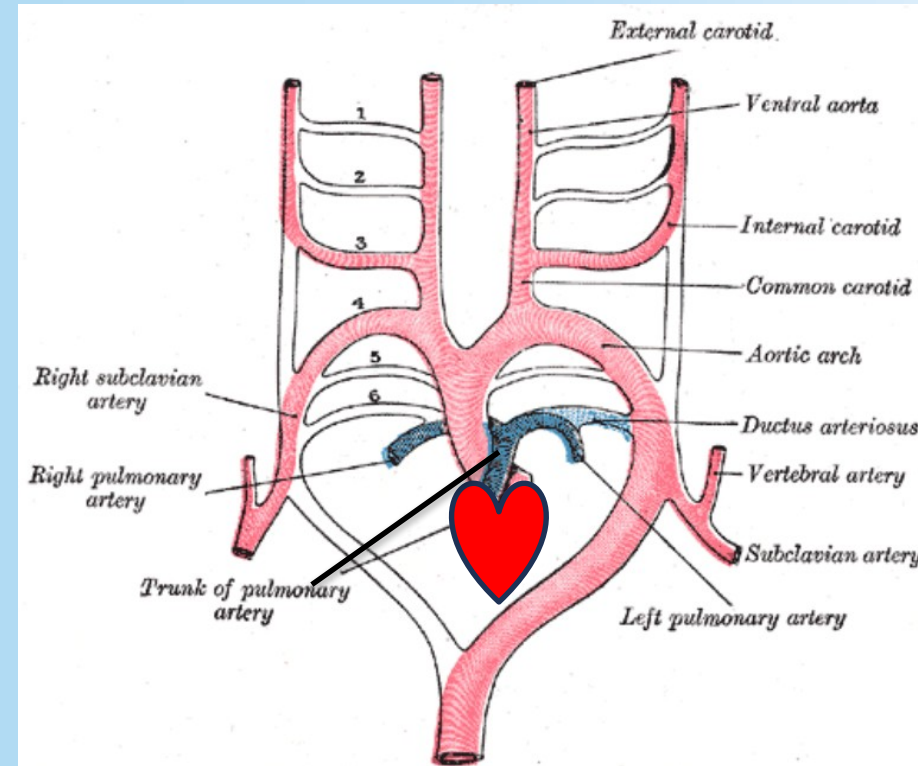
pRA- Primitive Right Atrium

pLA- Primitive Left Atrium

pRV-Primitive Right Ventricle

pLV-primitive Left Ventricle

aa- Aortic Arches



Cardiac looping establishes basic heart shape. The truncus arteriosus develops into the aortic sac, which connects to the arteries of the **pharyngeal arches** called the **aortic arches**.

1st Arch: Disappears; becomes maxillary arteries **“First is Max”**

2nd Arch: Disappears; becomes stapedial arteries **“Second is Stapedial”**

3rd Arch: Becomes carotid arteries **“3rd letter of “arCh”= Carotid”**

4th Arch: Becomes right subclavian and aortic arch **“fourth RS= right subclavian and for = aortic arch”**

5th Arch: Disappears completely.

6th Arch: Becomes pulmonary trunk, arteries and ductus arteriosus **“ 6 looks like a lung and bronchi”**

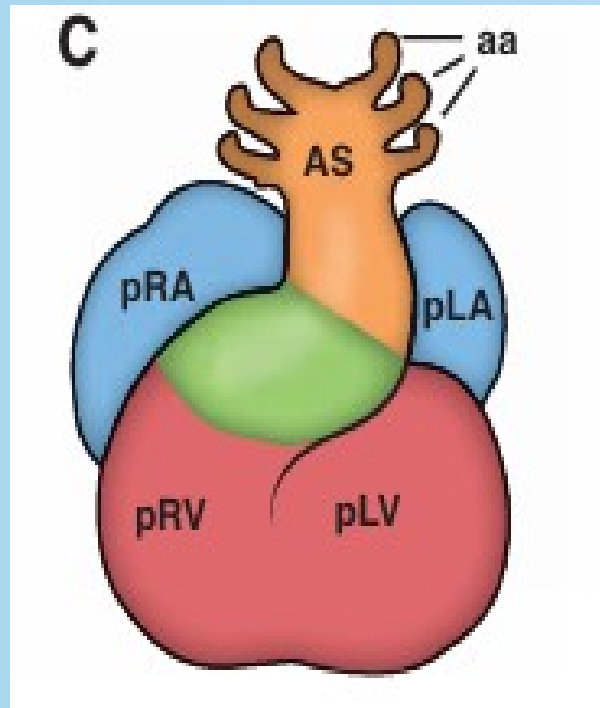
Development of Cardiac Septa

We have general heart shape. Now we must make walls to separate the atria and ventricles!

Neural Crest Cells (NCCs)
migrate to form a growth of cells
called **endocardial cushions**

Eventually, the
endocardial cushions
fuse together to form
septum intermedium

Development of Heart Septa



Endocardial cushion location after cardiac looping. It is behind bulbus cordis

Development of Heart Septa



Cells move off the endocardial cushions and heart wall to form a slitted annulus. These are the **leaflets of the mitral and tricuspid valve**. Endocardial cells then move downward and attach to the heart wall, forming **chordae tendinae**

A growth of tissue from the superior roof of the heart moves downwards, called **septum primum**, but does not fully connect to endocardial cushions. This gap is called **foramen primum**. This structure is present around day 27-34

Development of Heart Septa

Septum primum eventually reaches the endocardial cushions and foramen primum is sealed off at day 34. However, apoptosis occurs in a superior segment of septum primum, forming **foramen secundum**.

A second growth of tissue called **septum secundum** occurs to the right of septum primum. A gap remains between septum secundum and primum however, forming **foramen ovale**. We now have right and left atria

- Why do we have some kind of foramen between the atria in the heart during fetal development?
- It's to bypass pulmonary circulation because the placenta is oxygenating blood!
- How does foramen ovale seal?
- When we are born, blood is shunted to the lungs which returns to the left atrium. This increases left atrial pressure and slams the bendy septum primum on to the stiffer septum secundum, causing a seal → fossa ovalis
- If it does not seal, we have an ASD called **patent foramen ovale**
- **PFO** is usually harmless

Development of Heart Septa

Mesoderm migrates from the anterior wall of the primitive ventricles and moves backwards on the midline forming the **muscular part of the interventricular septum**. However, it does not connect to septum intermedium forming **interventricular foramen of the heart**

Endocardial cushion cells migrate off the septum intermedium forming the **membranous part of the interventricular septum**. It moves downwards until it fuses with the **muscular part of the IV septum**, sealing off the interventricular foramen of the heart. We now have right and left ventricles

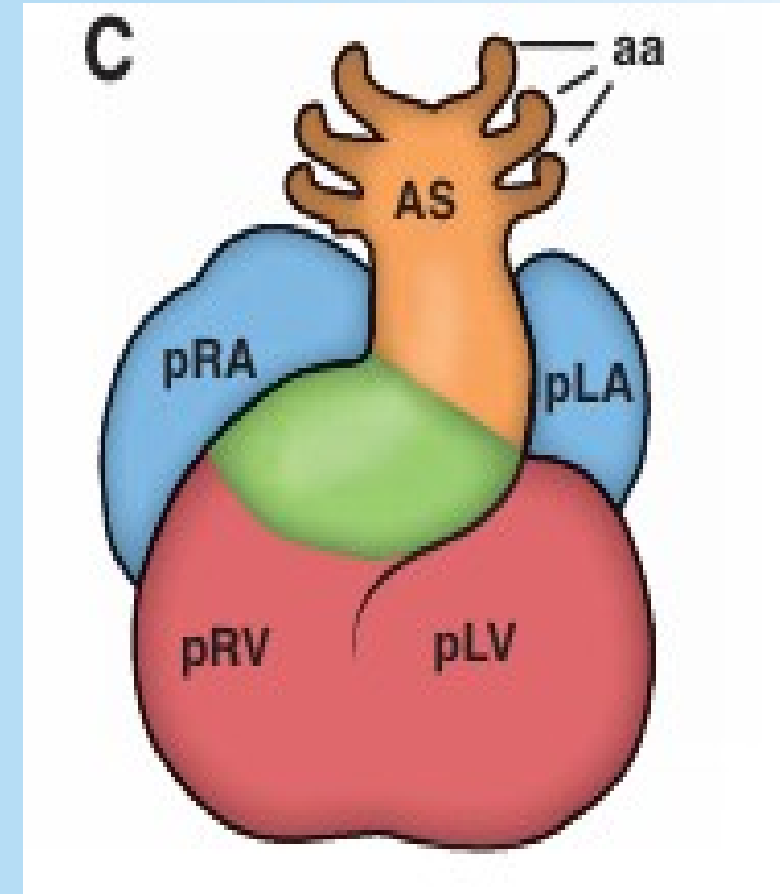
Development of Aorticopulmonary Septum

The pulmonary trunk and aorta are separate from each other when we are born

After cardiac looping we have the following heart shape:

Truncus Arteriosus is getting blood from both ventricles.

We have to form another septum!



Development of the Aorticopulmonary Septum

- Neural crest cells migrate from the hindbrain down into the truncus arteriosus and bulbus cordis to form ridges: **truncal ridges** and **bulbar ridges**
- These ridges grow toward each other in a spiral fashion and fuse to form the **aorticopulmonary septum**

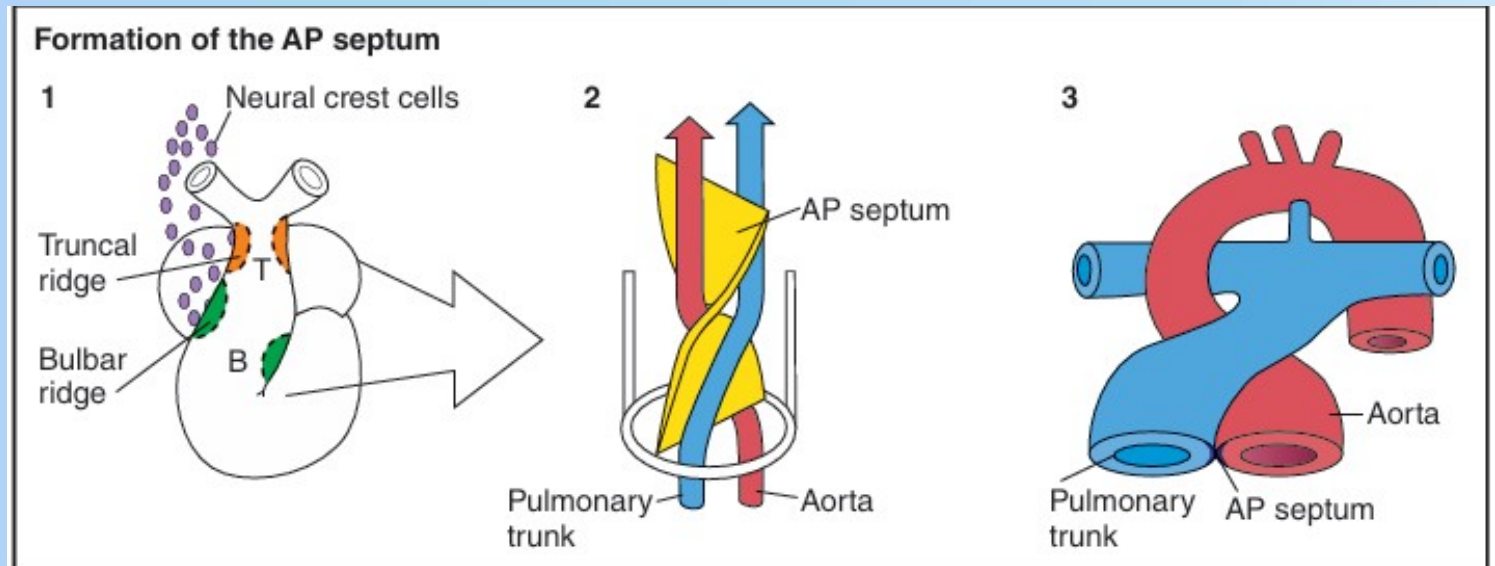


FIGURE 5.3. Formation of the aorticopulmonary (AP) septum. T = truncal ridges (orange), B = bulbar ridges (green).

Defects of the Aorticopulmonary Septum

Tetralogy of Fallot

Occurs if we have an asymmetric, unequal migration of neural crest cells causing a large diameter aorta and small diameter pulmonary trunk

Tetralogy: (PROVE)

1. Pulmonary Stenosis
2. Right Ventricular Hypertrophy
3. Overriding Aorta (Collecting blood from both ventricles)
4. VENTricular Septal Defect

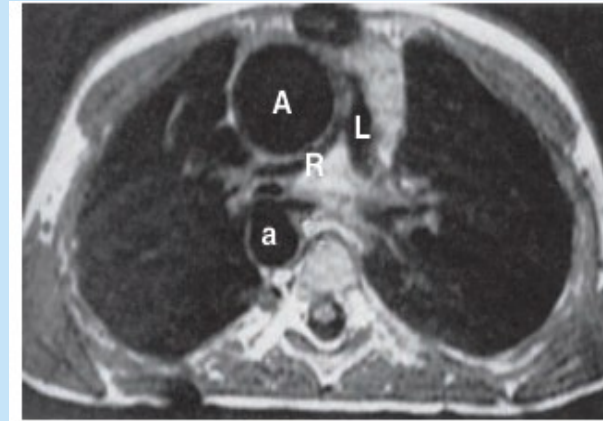
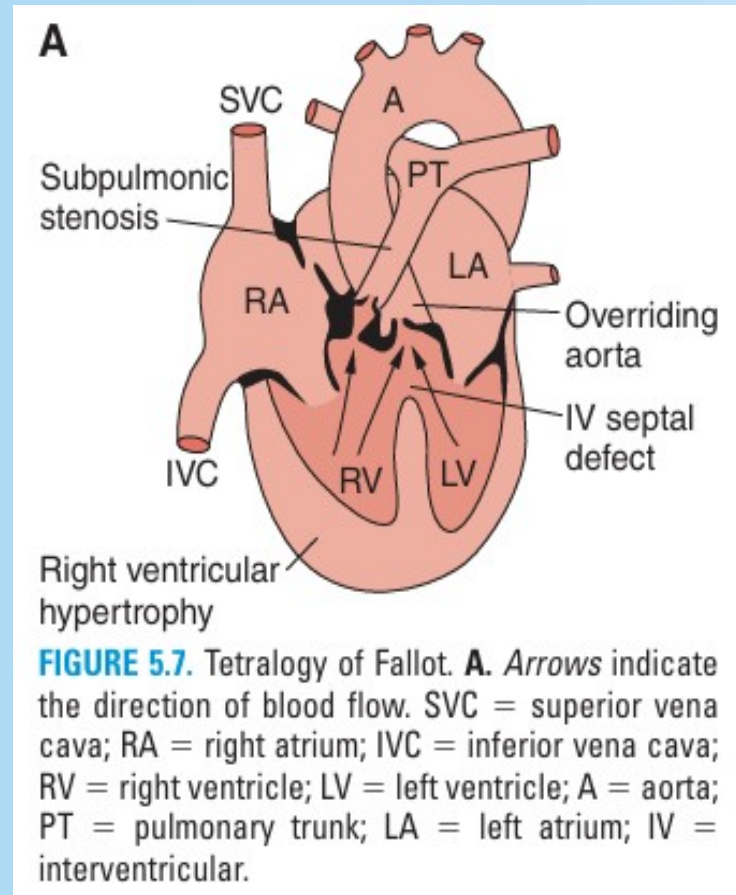


FIGURE 5.7. B. MRI. R = right pulmonary artery; L = left pulmonary artery; A = aortic arch; a = descending aorta.

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