

Development of the heart

Editing File

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(يَوْمَ لَا يَنْفَعُ مَالٌ وَلَا بَنُونَ (88) إِلَّا مَنْ أَتَى اللَّهَ بِقَلْبٍ سَلِيمٍ (89))

سورة الشعراء



Objectives

By the end of this lecture the student should be able to:



Describe the formation, sit, union divisions of the heart tubes.



Describe the formation and fate of the sinus venosus.



Describe the **partitioning** of the **common atrium and common ventricle**.



Describe the partitioning of the **truncus arteriosus**.



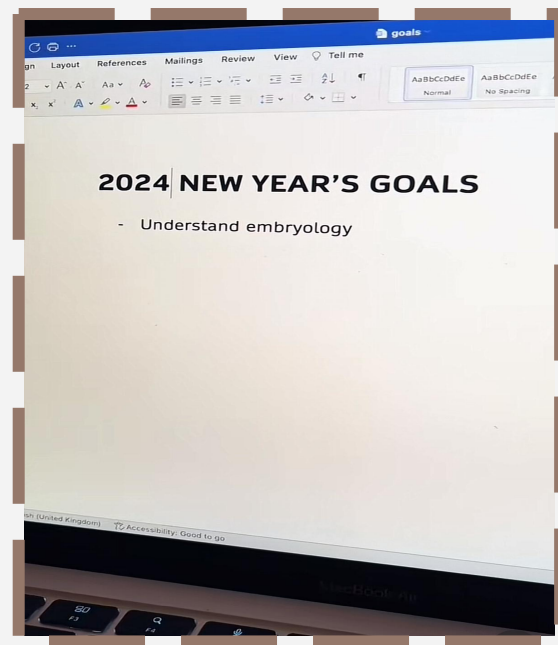
List the most common **cardiac anomalies**.



We Highly Recommend that you watch this video 🧑‍🎓, it is truly a **lifesaver**.



شرح د.ایمن خنفور



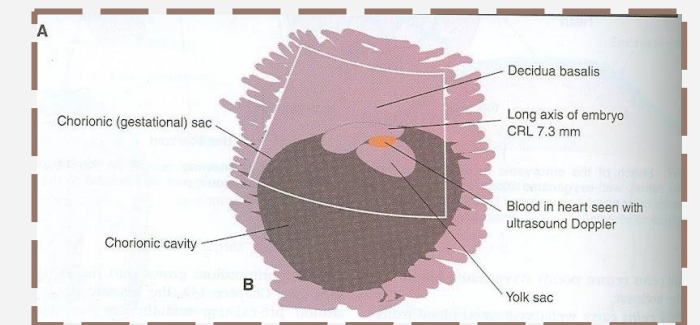
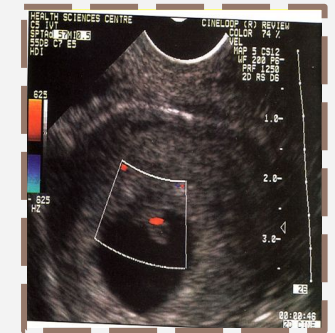
Development of the heart



Development of the heart



- 01 • The CVS is the **first major system to function** in the embryo.
- 02 • The heart **begins to beat** at (22nd- 23rd) days. (3rd week)
- 03 • Blood flow begins during the beginning of the 4th week and can be visualized by Ultrasound Doppler.



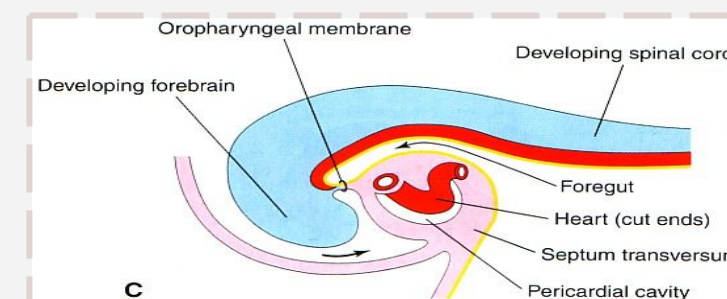
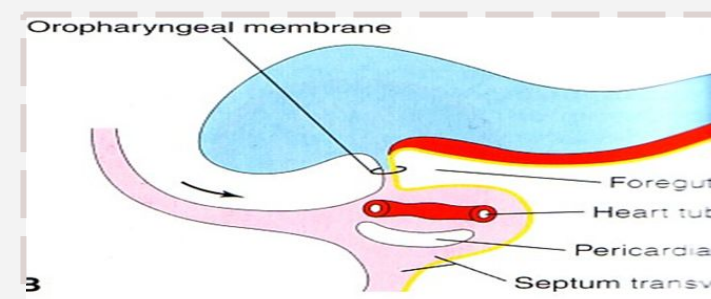
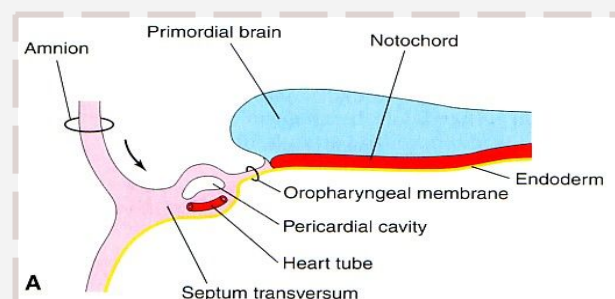
Formation of the Heart Tube

1 The heart is the **first functional organ** to develop

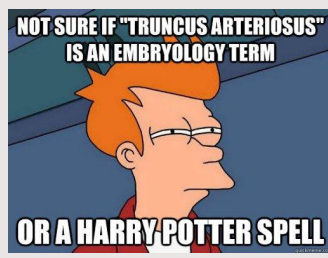
2 It develops from **splanchnic Mesoderm** in the wall of the yolk sac (**Cardiogenic Area**):
 - Cranial to the developing Mouth & Nervous system.
 -Ventral to the developing pericardial sac.

3 The heart primordium is **first evident at day 18** (as an Angioplasmic cords which soon canalize to form the 2 heart tubes)

4 As the **Head Fold completed** the developing heart tubes change their **position** and become in the ventral aspect of the embryo, dorsal to the developing Pericardial sac.



The cranial half of embryos during the fourth week (Longitudinal section)
 Note the effect of the head fold (arrows) on the heart's position and other structures.
 Fig. A and B the tubular heart and pericardial cavity move ventral to the foregut and caudal to the oropharyngeal membrane.
 Fig. C Note the change in positions of the pericardial cavity and septum transversum

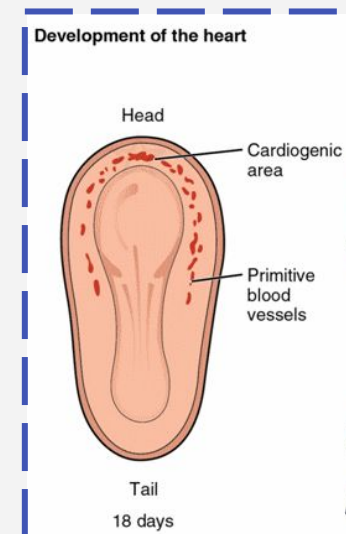
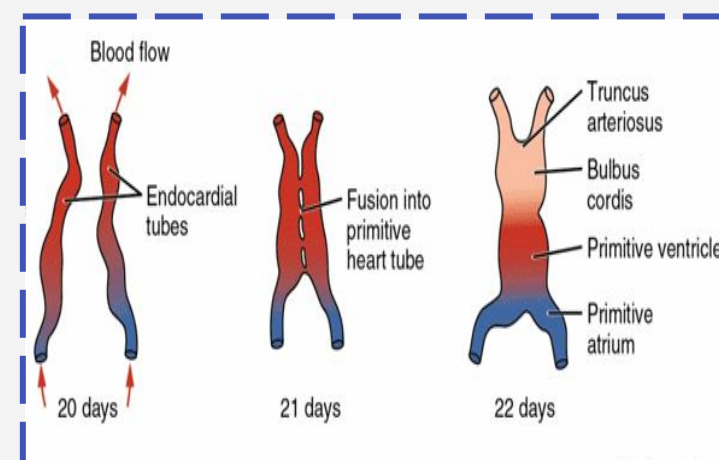


Heart Tube

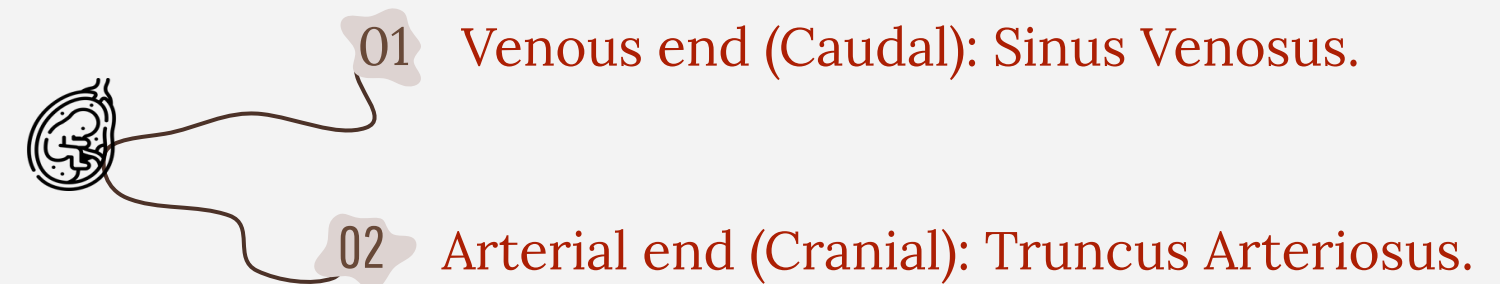


Development of the Heart Tube

- After the lateral folding of the embryo, the **2 heart tubes approach each other and fuse** to form a single **Endocardial Heart Tube** within the pericardial sac.
- Fusion of the two tubes occurs in a **Craniocaudal** direction.



The endocardial heart tube has 2 ends:

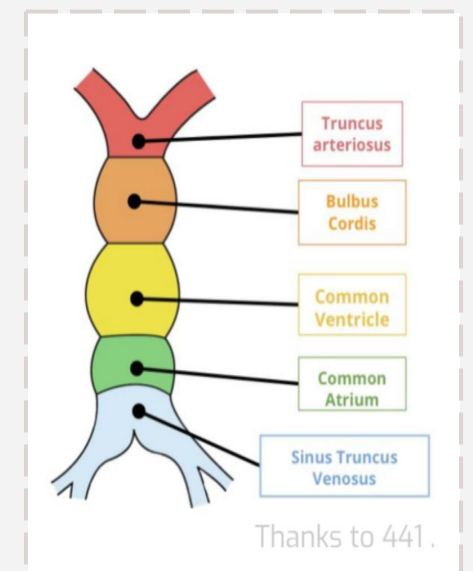
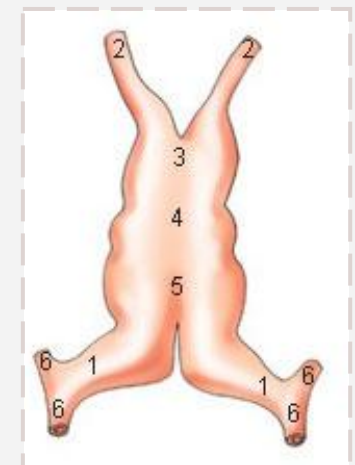


Fate of the Heart Tube

The heart grows faster than the pericardial sac, so it shows **5 alternate dilations separated by constrictions.**

These are:

- 1- Sinus Venosus يصير جزء من atrium ويختفي
- 2- Truncus Arteriosus تسوي pulmonary trunk & aorta
- 3- Bulbus Cordis يصير جزء من ventricle ويختفي
- 4- Common ventricle
- 5- Common Atrium



Thanks to 441.



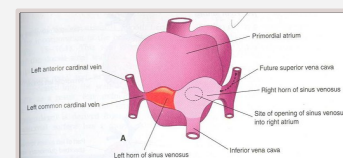
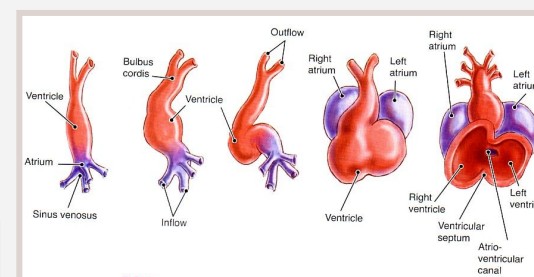
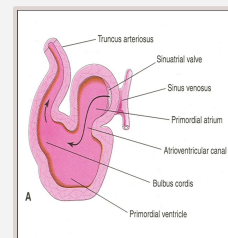
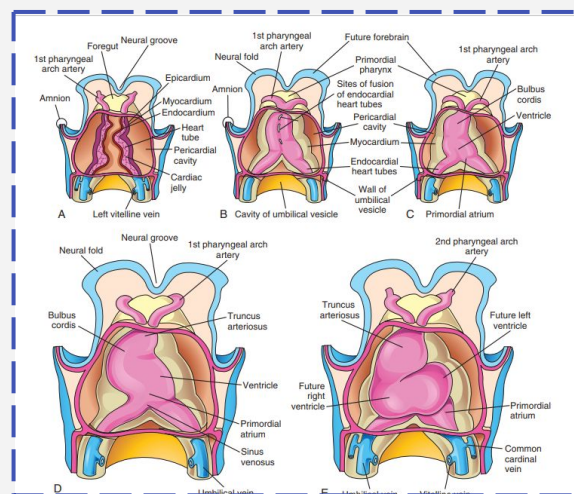
Shape of the Heart Tube:

U-Shaped Heart Tube

Why does the heart tube bend?

- The **Bulbus cordis** and **ventricle** grow faster than other regions.
- So the heart **bends** upon itself, forming the **U-shaped** heart tube, (**Bulboventricular loop**).

Fusion Of The Heart Tubes And Looping Of The Tubular Heart;



S-Shaped Heart Tube

As the heart tube develops it bends, **upon itself and forms S-shaped heart tube:**

- SO, the **Atrium and Sinus venosus** become Cranial in position & Dorsal to the Truncus arteriosus, Bulbus cordis, and Ventricle.
- By this stage the sinus venosus (opens in the dorsal surface of the atrium) has developed 2 lateral expansion, (Horns): Right and Left.

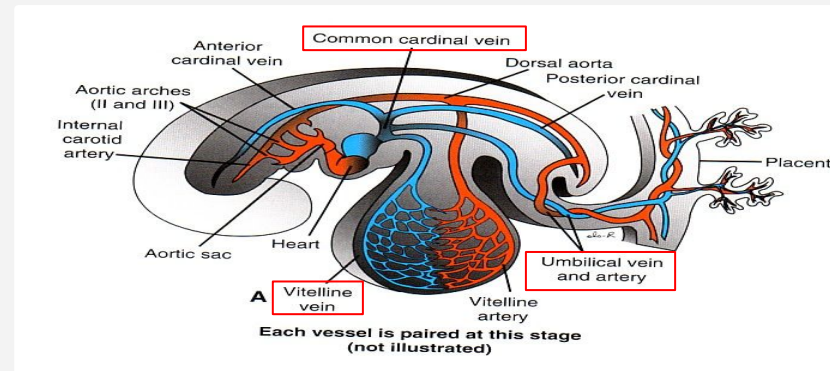
- Fig. A to C, Ventral views of the developing heart and pericardial region (22 to 35 days). Note: The ventral pericardial wall has been removed to show the developing myocardium and fusion of the two heart tubes to form a tubular heart.
- Fig. D and E, As the straight tubular heart elongates, it bends and undergoes looping, which forms a D-loop (D, dextro; rightward) that produces an S-shaped heart

Fate of Sinus Venosus

Veins Draining into Sinus Venosus:

Each horn of the **sinus venosus** receives **3 veins**:

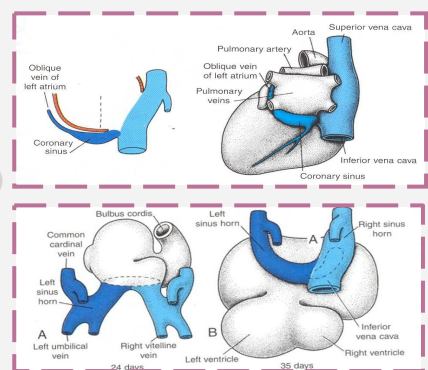
- 1- Common cardinal
- 2- Vitelline
- 3- Umbilical



- Common cardinal vein from the fetal body
- Vitelline from the yolk sac
- Umbilical from the placenta

Each vessel is paired at this stage (not illustrated)

Fate of Sinus Venosus



- 1 • The **Right Horn** forms the smooth posterior part of the right atrium; **sinus venosum**
- 2 • The **Left Horn** and Body atrophy and form the **Coronary Sinus**
- 3 • The **left Common cardinal vein** forms the **Oblique Vein** of the left Atrium.

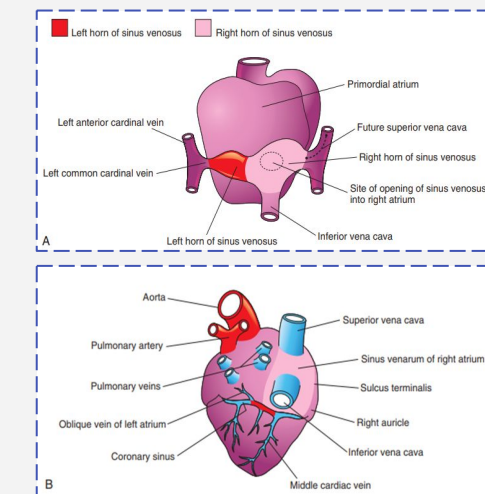
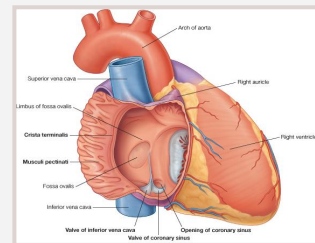
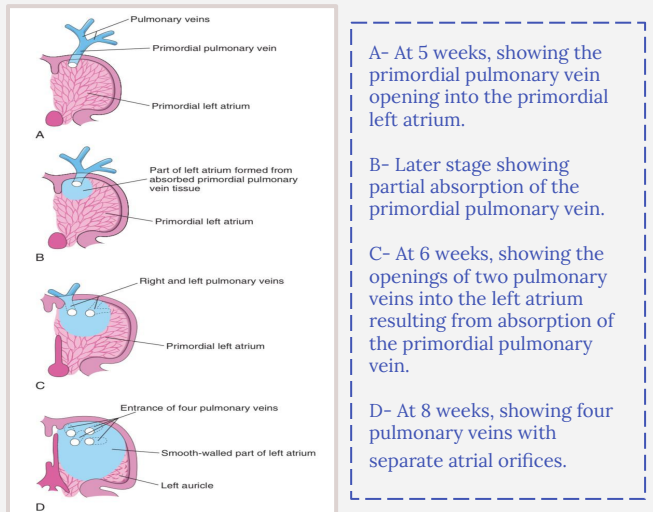


Fig. A shows the fate of the sinus venosus. Dorsal view of the heart (approximately 26 days) showing the primordial atrium and sinus venosus. **B.** Dorsal view at 8 weeks after incorporation of the right horn of the sinus venosus into the right atrium. The left horn of the sinus horn becomes the coronary sinus.

Development of the atriums

Development of the atriums

Right Atrium	Left Atrium
<p>The right atrium is developed from two parts:</p> <ul style="list-style-type: none"> -Rough Trabeculated anterior part (musculi pectinati) of the right atrium is derived from the primordial common atrium. -The right horn of the sinus venosus forms the smooth posterior part of the right atrium. -These two parts are demarcated by the crista terminalis internally and sulcus terminalis externally. 	<p>The left atrium is developed from two parts:</p> <ul style="list-style-type: none"> -Rough Trabeculated part: derived from the common primordial atrium. -The smooth part: derived from the absorbed pulmonary veins.

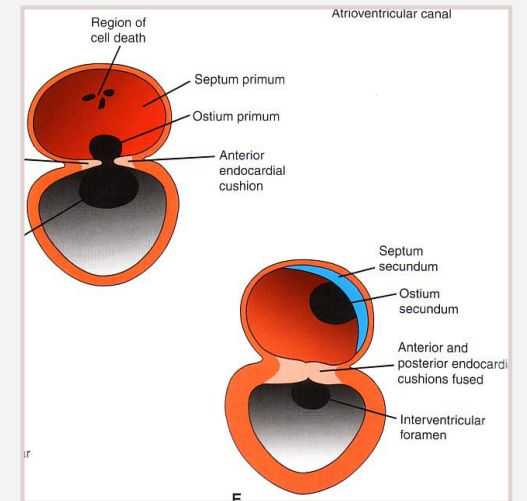


demarcated here means setting the boundaries or limits of something.

Partitioning of Primordial Heart

- 1 Atrioventricular canal.
- 2 Common atrium.
- 3 Common ventricle.
- 4 Truncus arteriosus & Bulbus cordis.

- It begins by middle of 4th week.
- It is completed by the end of the 5th week.

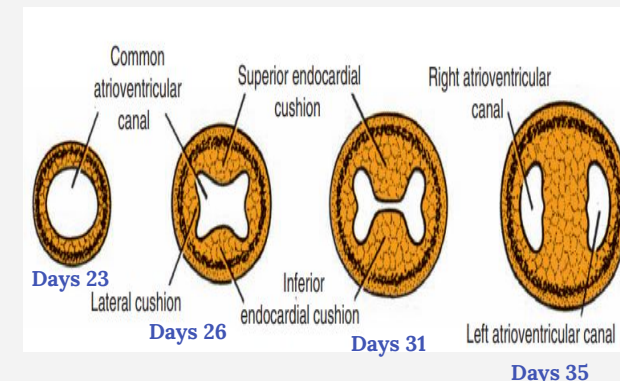


★ Endocardial cushions:

They appear around the middle of the 4th week as Mesenchymal Proliferation.

They participate in formation of :

- 1 A.V (Atrioventricular) canals and valves.
- 2 Atrial septa.
- 3 Membranous part of Ventricular septum.
- 4 Aortic and Pulmonary channels (Spiral septum).



Formation of the septum in the atrioventricular canal. The initial circular opening widens transversely.

Partitioning of the atrioventricular canal

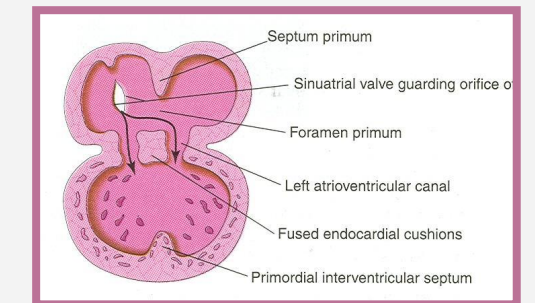
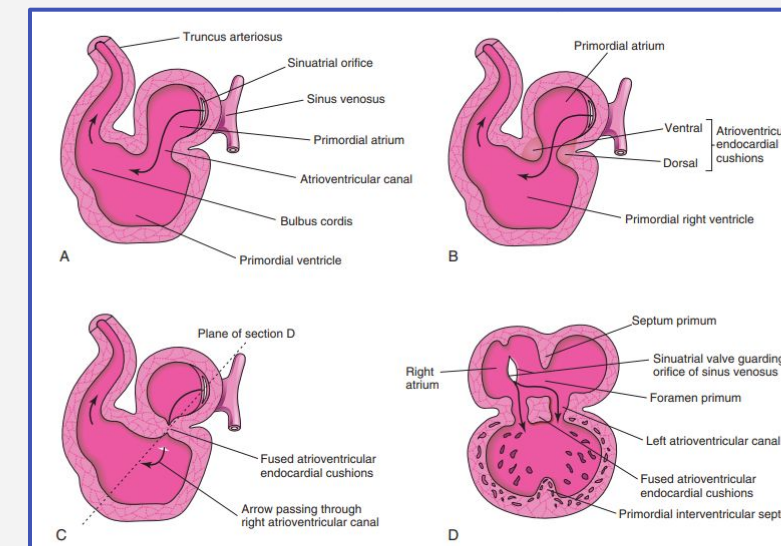
Partitioning of the atrioventricular canal

Two Endocardial Cushions are formed on the dorsal and ventral walls of the AV canal.

The AV endocardial cushions approach each other and fuse to form Septum Intermedium.

Dividing the AV canal into right & left canals.

These canals partially separate the primordial atrium from the ventricle.



- **A and B-** Sagittal sections of the heart during the 4th and 5th weeks, showing the division of the atrioventricular canal. The arrows are passing through the sinuatrial orifice.
- **C-** Fusion of the AV endocardial cushions.
- **D-** Coronal section of the heart at the plane shown in C.

Note that the septum primum and interventricular septa have started to develop

(إِنَّ مَعَ الْعُسْرِ يُسْرًا) (فَإِنَّ مَعَ الْعُسْرِ يُسْرًا)
[سورة الشرح: 5,6].

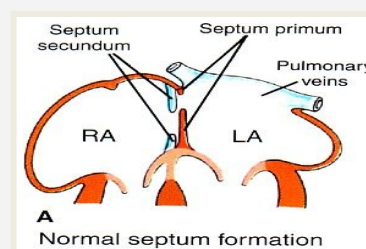
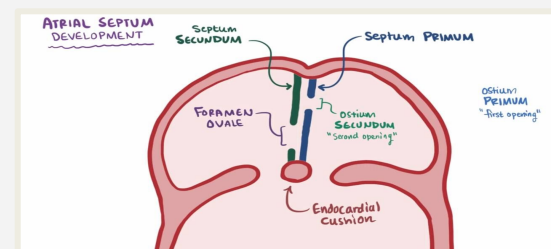
Partition of Common Atrium & Ventricle



Quick helpful video

Partition of Common Atrium

<p>★ Septum Primum</p>	<ul style="list-style-type: none"> It is sickle-shaped septum that grows from the roof of the common atrium towards the fusing endocardial cushions (septum intermedium). 	<ul style="list-style-type: none"> So it divides the common atrium into: right & left halves.
<p>Ostium/ Foramen Primum</p>	<ul style="list-style-type: none"> The two ends of septum primum reach to the growing endocardial cushions before it's central part. Then, the septum primum bounds a foramen called ostium primum. 	<ul style="list-style-type: none"> It serves as a shunt, enabling the oxygenated blood to pass from right to left atrium. The ostium primum become smaller and disappears as the septum primum fuses completely with the septum intermedium to form the AV septum.
<p>★ Septum Secundum</p>	<ul style="list-style-type: none"> The upper part of septum primum that is attached to the roof of the common atrium shows gradual resorption forming an opening called ostium secundum. 	<ul style="list-style-type: none"> Another septum descends on the right side of the septum primum is called Septum Secundum. it forms an incomplete partition between the two atria. Consequently a valvular oval foramen forms, (Foramen Ovale).



Fate of foramen ovale

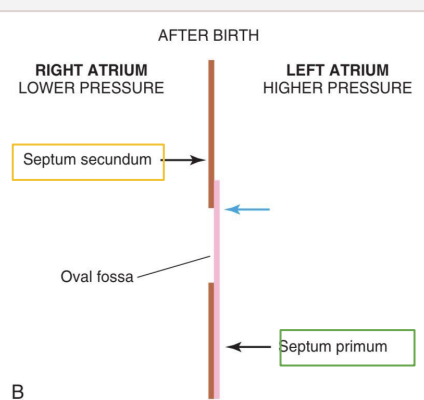
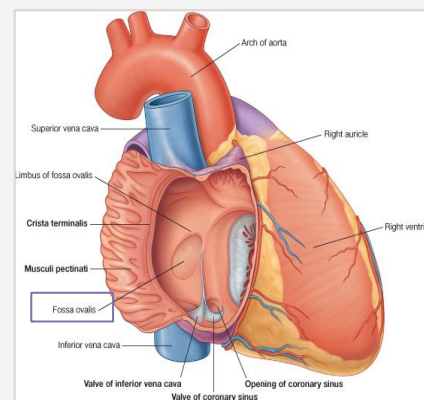
1 At birth when the lung circulation begins, the pressure in the left atrium increases.

2 The valve of the foramen ovale is pressed against the septum secundum and obliterates the foramen ovale.

3 Its site is represented by the **Fossa Ovalis**: (*)

Its **floor** represents the persistent part of the **septum primum**. (*)

Its **limbus** (anulus) is the lower edge of the **septum secundum**. (*)



Partition of Common Atrium & Ventricle

Partitioning of Primordial Ventricle

Interventricular septum consists of:

1 Muscular part:

1 Division of the primordial ventricle is first indicated by a **median muscular ridge, the primordial interventricular septum.**

2 Membranous part:

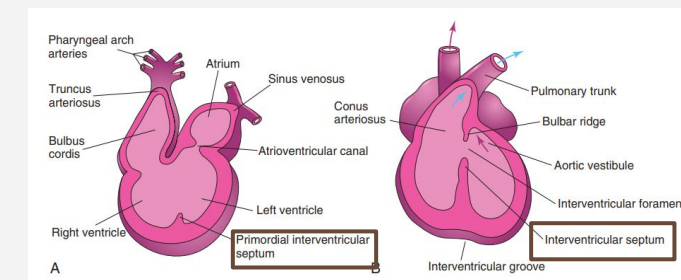
1 Formed by a tissue extension from the right side of the **Endocardial Cushion**, and closure of **interventricular foramen.**

2 It is a thick crescentic fold which has a concave upper free edge.

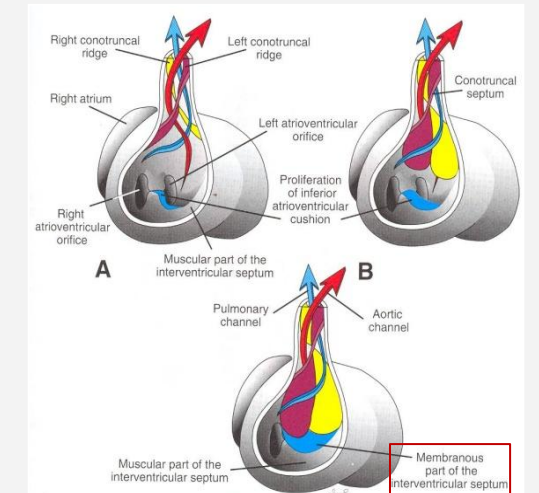
2 This tissue merges with the **Aorticopulmonary septum.** (Spiral septum)

3 This septum bounds a temporary connection between the two ventricles called **Interventricular foramen.** usually closes by the end of the **seventh week** as the **bulbar ridges** fuse with the **endocardial cushion.**

3 And with the thick **Muscular part of the IV** (interventricular) **septum.**



Incorporation of the bulbus cordis into the ventricles.



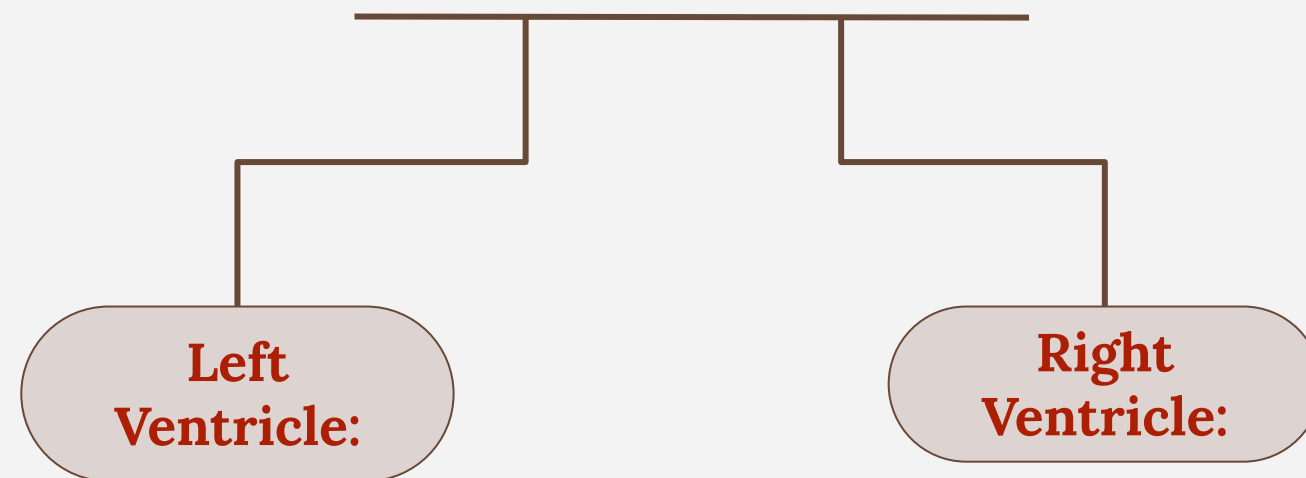
Therefore, the pulmonary trunk is in communication with the right ventricle and the aorta communicates with the left ventricle.

- the interventricular septum results from the fusion of tissues from three sources:
 - the **right bulbar ridge,**
 - the **left bulbar ridge,** and
 - the **endocardial cushion.**

Partition of Common Atrium & Ventricle

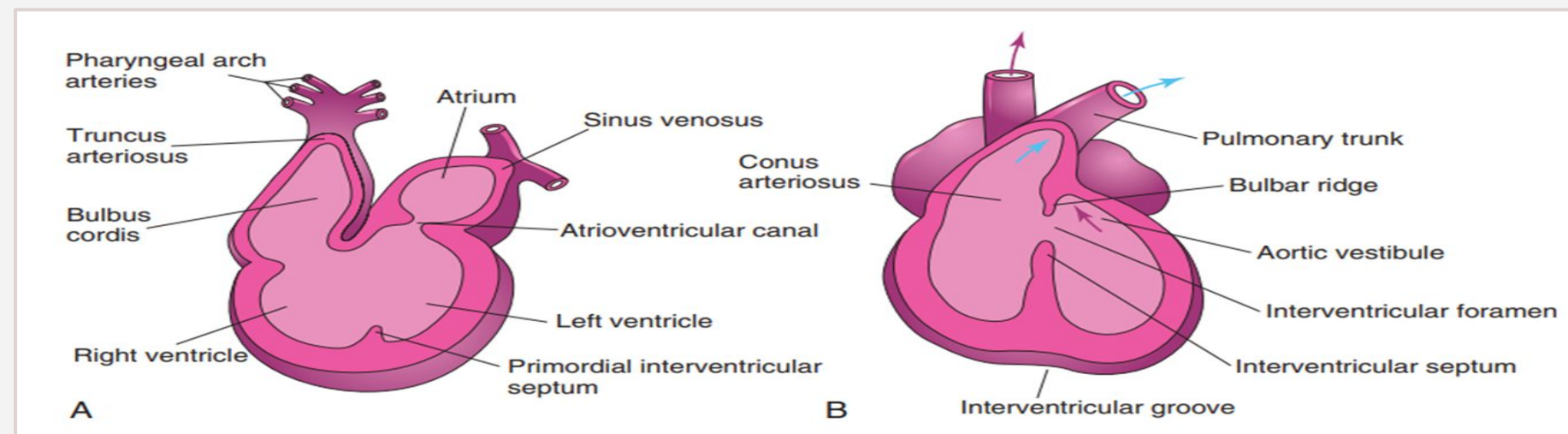
Bulbus Cordis

The **bulbus** cordis forms the smooth upper part of the two ventricles.



Aortic Vestibule leading to ascending aorta.

Conus Arteriosus or (Infundibulum) which leads to the pulmonary trunk.



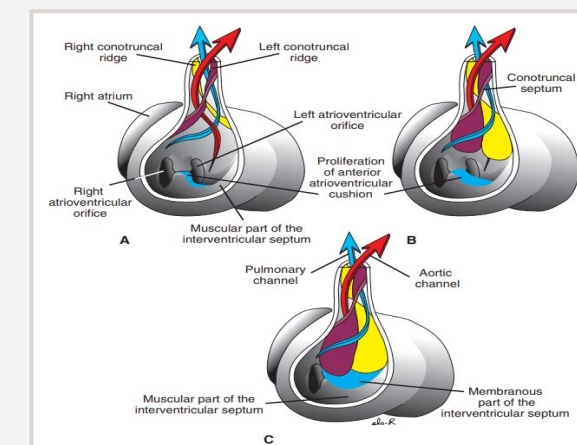
Partition of Truncus Arteriosus

In the **5th week**, proliferation of mesenchymal cells (**Endocardial Cushions**) appear in the wall of the **truncus arteriosus**, they form a **Spiral Septum**:

A. It divides the **Lower part** of the **Truncus Arteriosus** into **Right & Left** parts

B. It divides the **Middle** part of **Truncus Arteriosus** into **Anterior & Posterior** parts.

C. It divides the **Upper** part of the **Truncus Arteriosus** into **Right & left** parts.





ASD

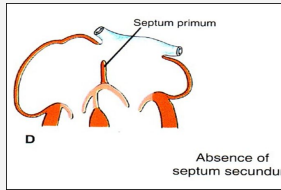
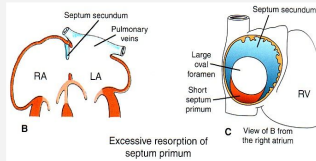
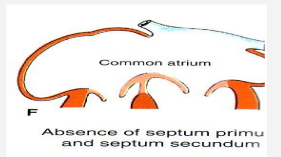
★ Major Cardiac Anomalies



VSD

👶 Atrial Septal Defects (ASD):

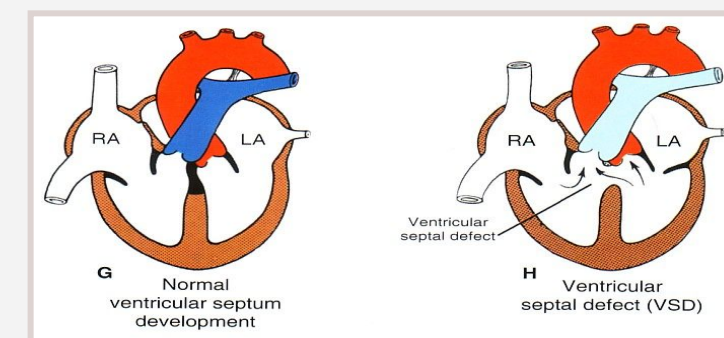
- ASD is a common CHD (Congenital Heart Defect) and occurs more frequently in females than males (2:1).
- The most common form of ASD is patent foramen ovale.
- A probe patent foramen ovale is present in up to 25% of people. (Probe patent foramen ovale results from incomplete adhesion between the flap-like valve of the foramen ovale and the septum secundum after birth).

Types	Absence of Septum Secundum . (ostium secundum defect)	
	Large (Patent) foramen ovale : Excessive resorption of septum primum. (ostium primum defect)	
	Absence of both septum primum and septum secundum, leads to Common Atrium .	
	Sinus Venosus Defect (very rare defect)	

The first two types of ASD is relatively common

👶 Ventricular Septal Defect (VSD):

- Known as **Roger's disease**.
- The most common types of CHDs, accounting for approximately 25% of heart defects. Occurs more frequently in males than in females. Frequently, during the first year, 30% to 50% of small VSDs close spontaneously.
- Absence of the **Membranous** part of interventricular septum (**persistent IV -interventricular- Foramen**).
- Usually accompanied by other cardiac defects.
- **Membranous VSD (most common)** results from failure of an extension of subendocardial tissue to grow from the right side of the endocardial cushion and fuse with the aorticopulmonary septum and the muscular part of the interventricular septum.
- **Muscular VSD** is less common and may appear anywhere in the muscular part of the interventricular septum. Sometimes there are multiple small defects, producing what is sometimes called the "Swiss cheese" VSD.



★ Question from doctor:
which one of the major cardiac anomalies appears more in Females?
Ans. is ASD



ToF

★ Major Cardiac Anomalies



TGA

Tetralogy of Fallot: (Fallot's Tetralogy)

01

VSD. (Ventricular Septal Defect)

02

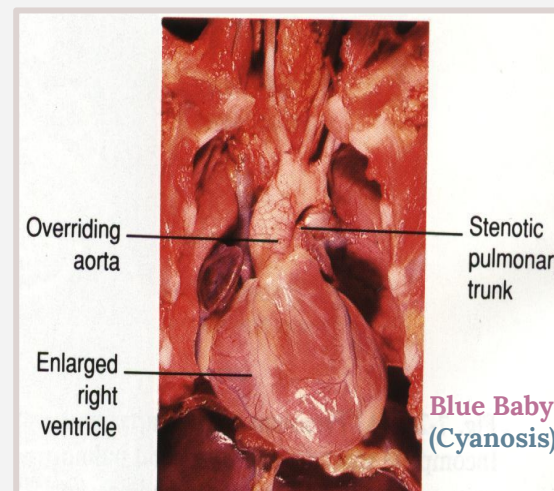
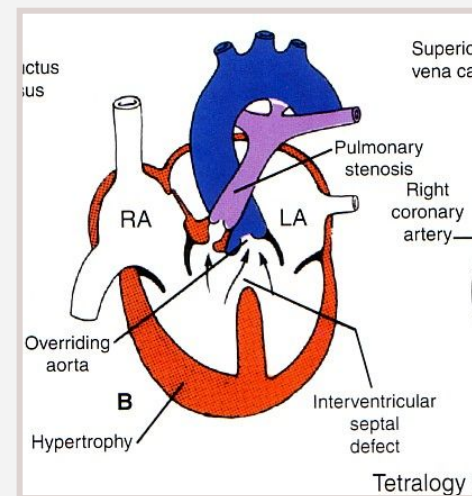
Pulmonary stenosis.
تضييق في Pulmonary valve

03

Overriding of the aorta.
الـ Aorta قاعد على مكان VSD ويجيه دم من RV

04

Right ventricular hypertrophy.
نتيجة زيادة الضغط على RV

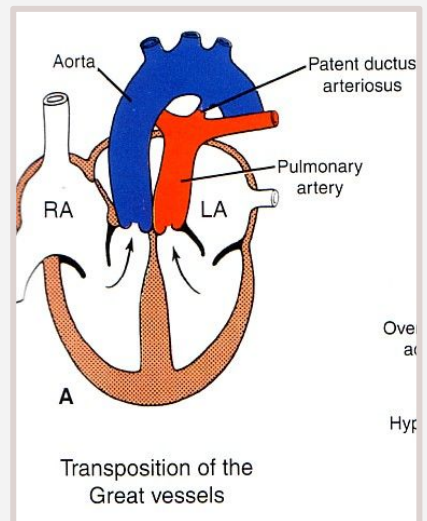


Transposition of Great Arteries (TGA)

❖ **TGA** is due to abnormal rotation or malformation of the aorticopulmonary septum, so the **right ventricle joins the aorta, while the left ventricle joins the pulmonary artery.**

❖ It is one of the most common causes of **cyanotic heart disease** in the newborn.

❖ Often associated with **ASD** or **VSD**.

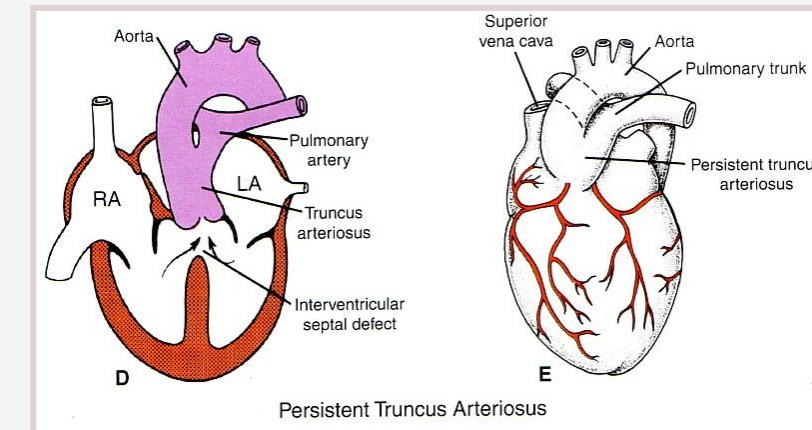


Note from 443:
The ones who have cyanosis:
1- Tetralogy of Fallot.
2- Transposition of Great Arteries.

★ Major Cardiac Anomalies



Persistent Truncus Arteriosus



1

1- It is due to
Failure of the development
of the aorticopulmonary
(spiral) septum.

2

**2- It is usually accompanied
with VSD.**
It forms a single arterial trunk
arising from the heart and
supplies the **systemic ,
pulmonary & coronary
circulations.**

Note from doctor:

Ductus arteriosus and **ductus venosus** is a normal shunt
(bypass) in the fetal circulation.

MCQs:

1	When can a medical professional hear the fetus's heartbeat?			
	22 to 23 days	17 to 19 days	19 to 20 days	27 to 30 days
2	Which part of the primitive heart tube gives rise to the pulmonary trunk and the aorta?			
	Sinus venosus	Bulbus cordis	Common Atrium	Truncus Arteriosus
3	The smooth part of the left atrium is formed by?			
	Common Atrium	Absorbed pulmonary veins	Primordial common atrium	Bulbus Cordis
4	The Septum Primum develops into which ONE of the following?			
	Crista Terminalis	Floor of the Fossa Ovalis	Limbus Ovalis	Septum Intermedium
5	A 4-year-old girl came to the ER with shortness of breath, palpitations and cyanosis. She has ASD (incomplete interatrial septum). A defect in which area of the following may cause this condition?			
	Ductus Arteriosus	Ductus Venosus	Fossa Ovalis	Truncus Arteriosus
6	A new born baby was admitted to the hospital with hypoxia and cyanosis. He later diagnosed with Tetralogy of Fallot. Which one of the following is a characteristic of his disease?			
	ASD	Aortic stenosis	Overriding of aorta	Left ventricular hypertrophy

Meet our team!

Leader

**Jana
Alomairini**

Leader

**Abdulrahman
Alhusayni**

Member

**Reema
Aldhabaan**

Member

**Abdulelah
Aljadaan**



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