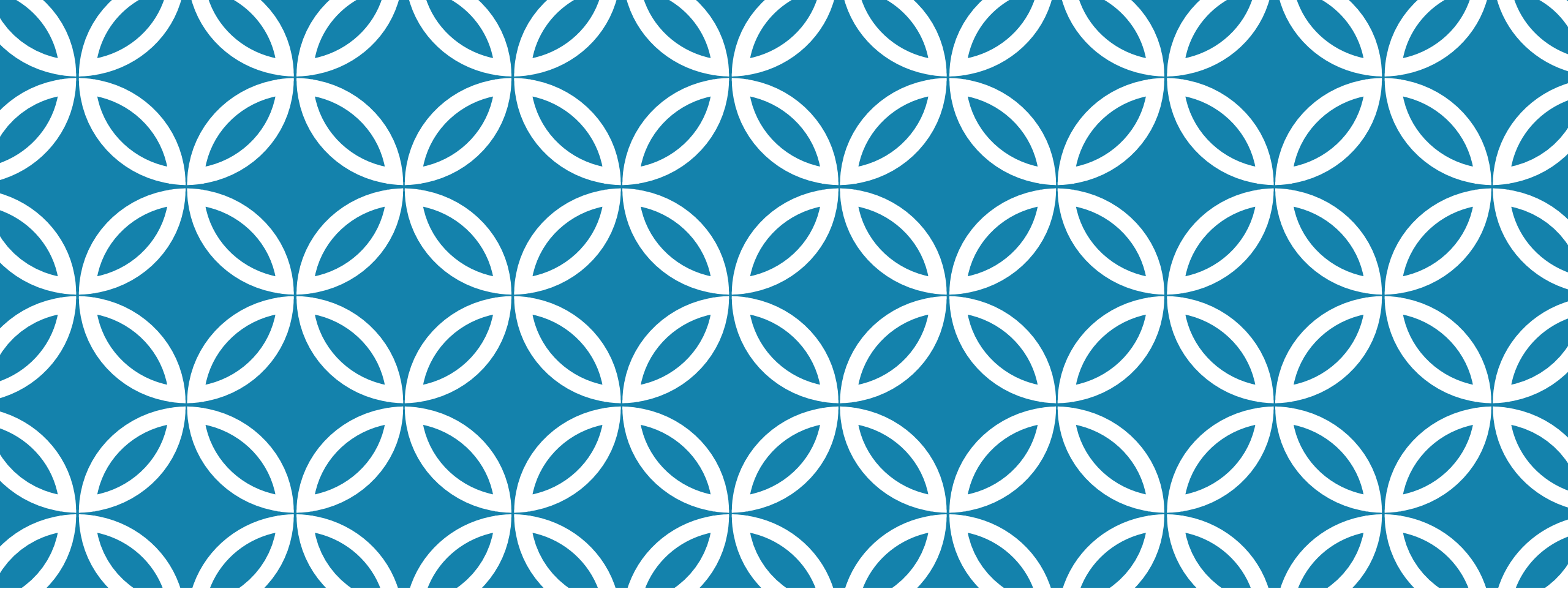




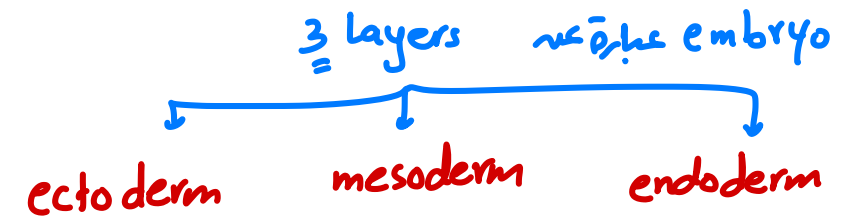
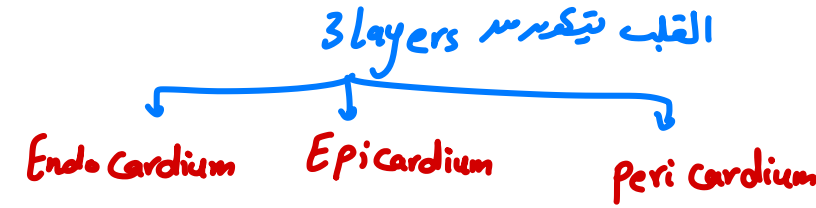
CARDIAC EMBRYOLOGY 1

THE HEART TUBE

Dr. Sawan

J. Shurab 

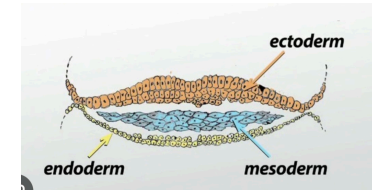
SOURCES OF HEART DEVELOPMENT



1. Pericardial sac:

It forms from the cranial part of intraembryonic celom

Its visceral layer will form the epicardium

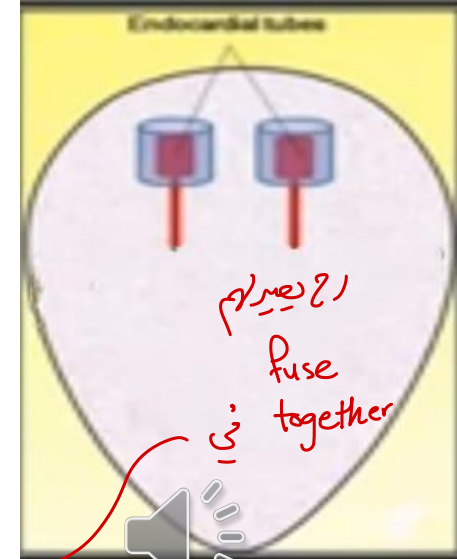


2. Endocardial heart tube:

(intra embryonic / Pericardium visceral mesoderm) (أصل Pericardium / intra embryonic Coelom) يتكون من

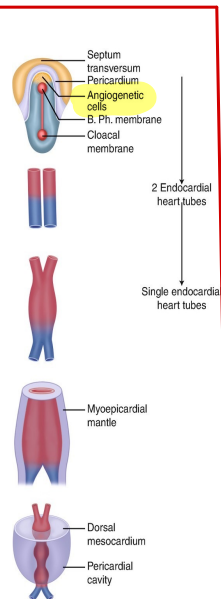
The angiogenetic cell forms clusters that develop at the area of cardiogenic plates to form 2 tubes that will fuse in a cranio caudal direction except the two ends

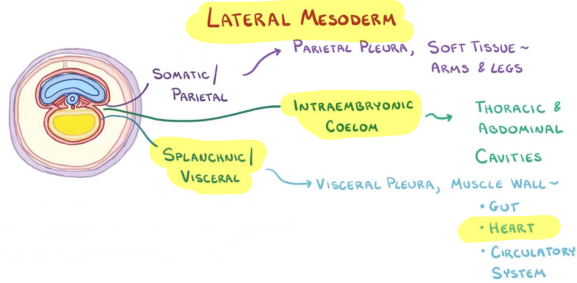
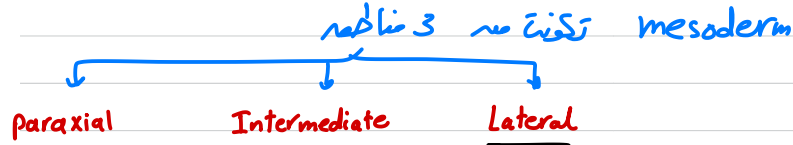
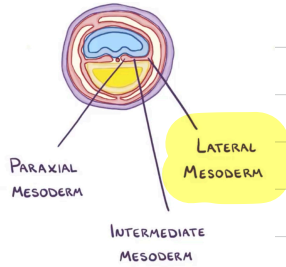
This will form the endocardium



embryo ← بصيرته folding

Lateral + Cranio caudal folding





مناطق جوفية

intraembryonic Coelom

قسم Lateral إلى

منطقة جوفية

visceral

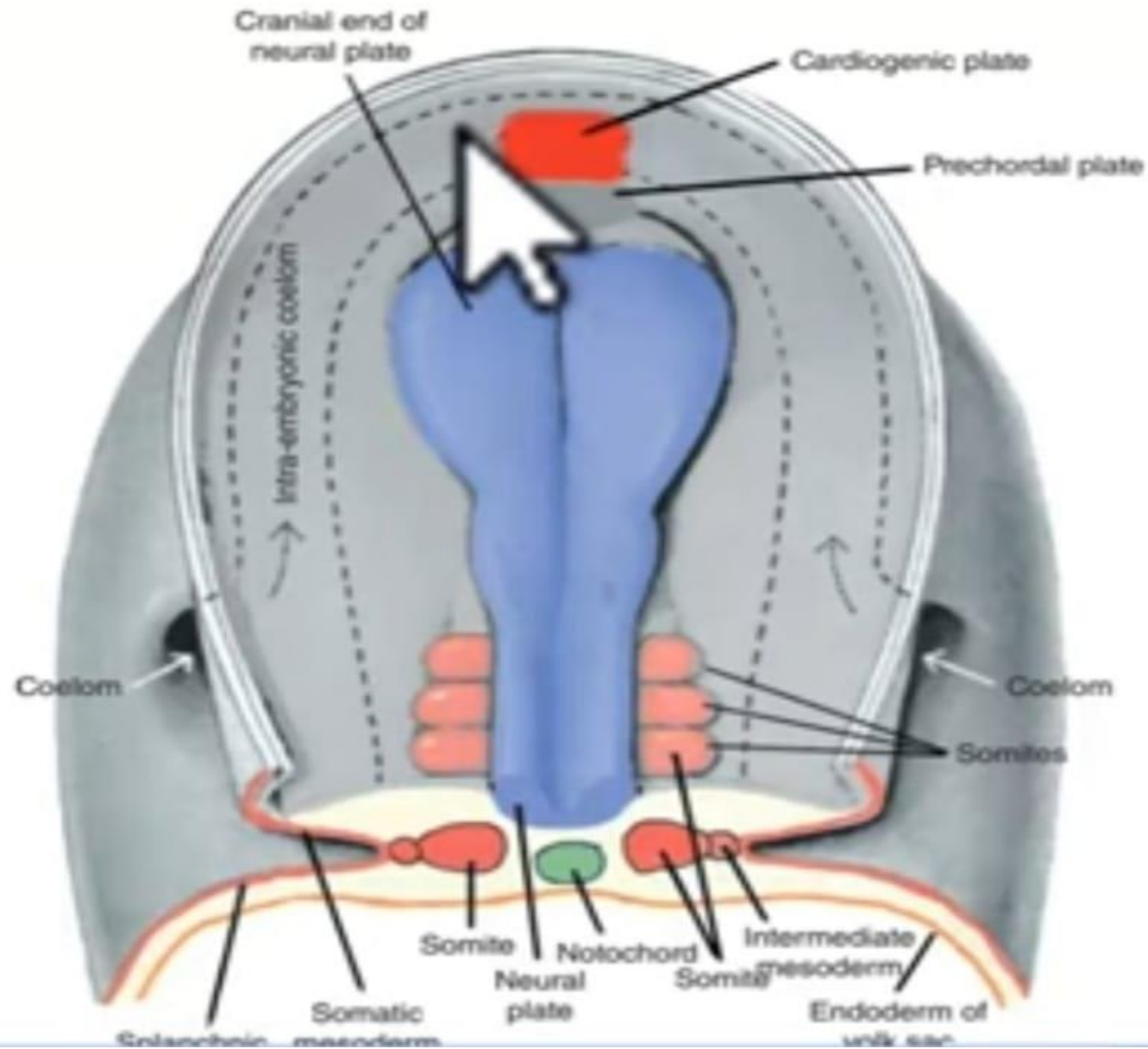
↓
مع تنبؤ من
organs
(Heart)

منطقة جوفية

parietal

↓
مع تنبؤ
pleura
peritoneum
abdomen

ape
mbryonic
nic cavity



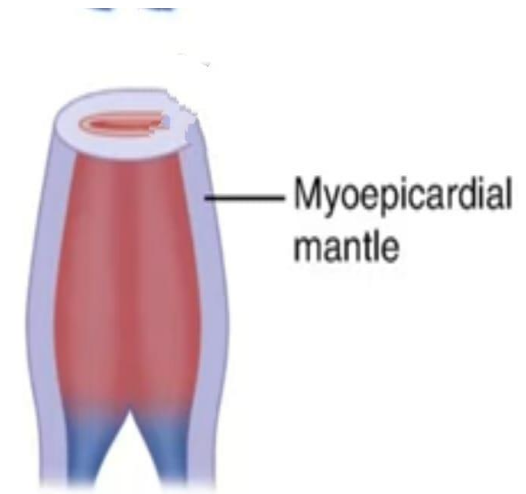
3. Myoepicardial mantle:

It will form between the heart tube and pericardial sac forming a coat around the heart tube

This will form the myocardium

تشكل من mesodermal cells
في visceral layer تحت
tubes intraembryonic coelom

حول endocardium tube من جميع الاتجاهات



Notes:

1. CVS is the first system to develop

It starts to beat at the middle of the third week

2. All these sources are mesodermal in origin

endocardium myocardium pericardium



المنطقة التي يلتقي فيها
ectoderm و endoderm

منطقة في الوسط ←
mesoderm

BEFORE FOLDING:

- The buccopharyngeal membrane (the future mouth) was situated caudally
- The septum transversum (the future diaphragm) was situated cranially

← (heart) The cardiogenic area was in between.

cardiogenic plate ← The pericardial sac → dorsal

AFTER FOLDING:

- The buccopharyngeal membrane becomes cranial
- The septum transversum becomes caudal
- The cardiogenic area is in between but the pericardial sac becomes ventral to the heart tube
← هنا heart رح يصير فيه pericardium
- So, invagination occurs from the dorsal aspect of pericardium
(heart)



Sources of the heart development

Pericardial sac

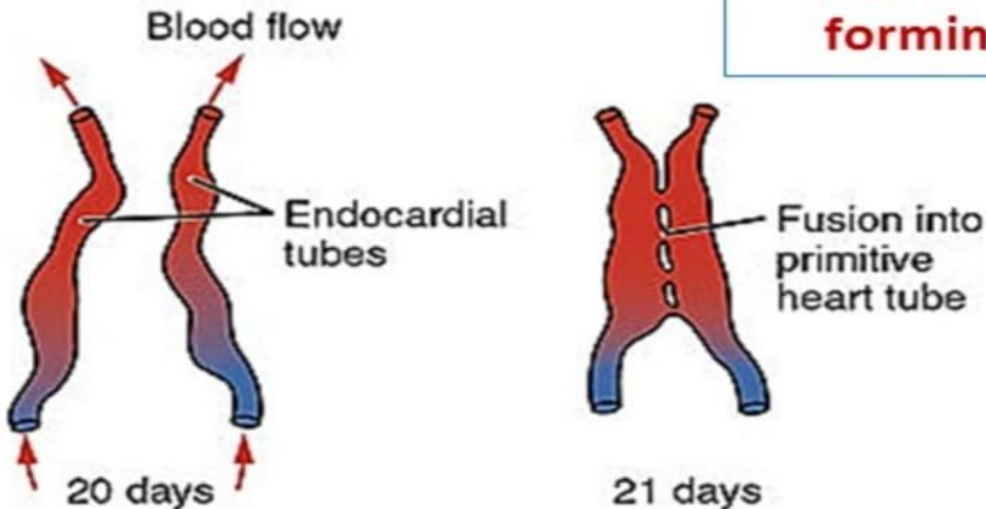
- It is the **transverse (cranial)** part of the **intraembryonic coelom**.

Endocardial heart tube

- **Angiogenic cell** clusters develop at the **area** of **cardiogenic plate** to form **right and left endocardial heart tubes**.
- **Both tubes fuse** together **forming a single tube**.

Myo-epicardial mantle

- This layer is **situated between heart tube and pericardial sac**.
- **After invagination** of the sac by the heart tube, the **mantle will form a coat** around the heart tube.



CVS is the **first** system to **develop**. It starts at the **middle** of the **3rd** week when the **heart** starts to **beat**.

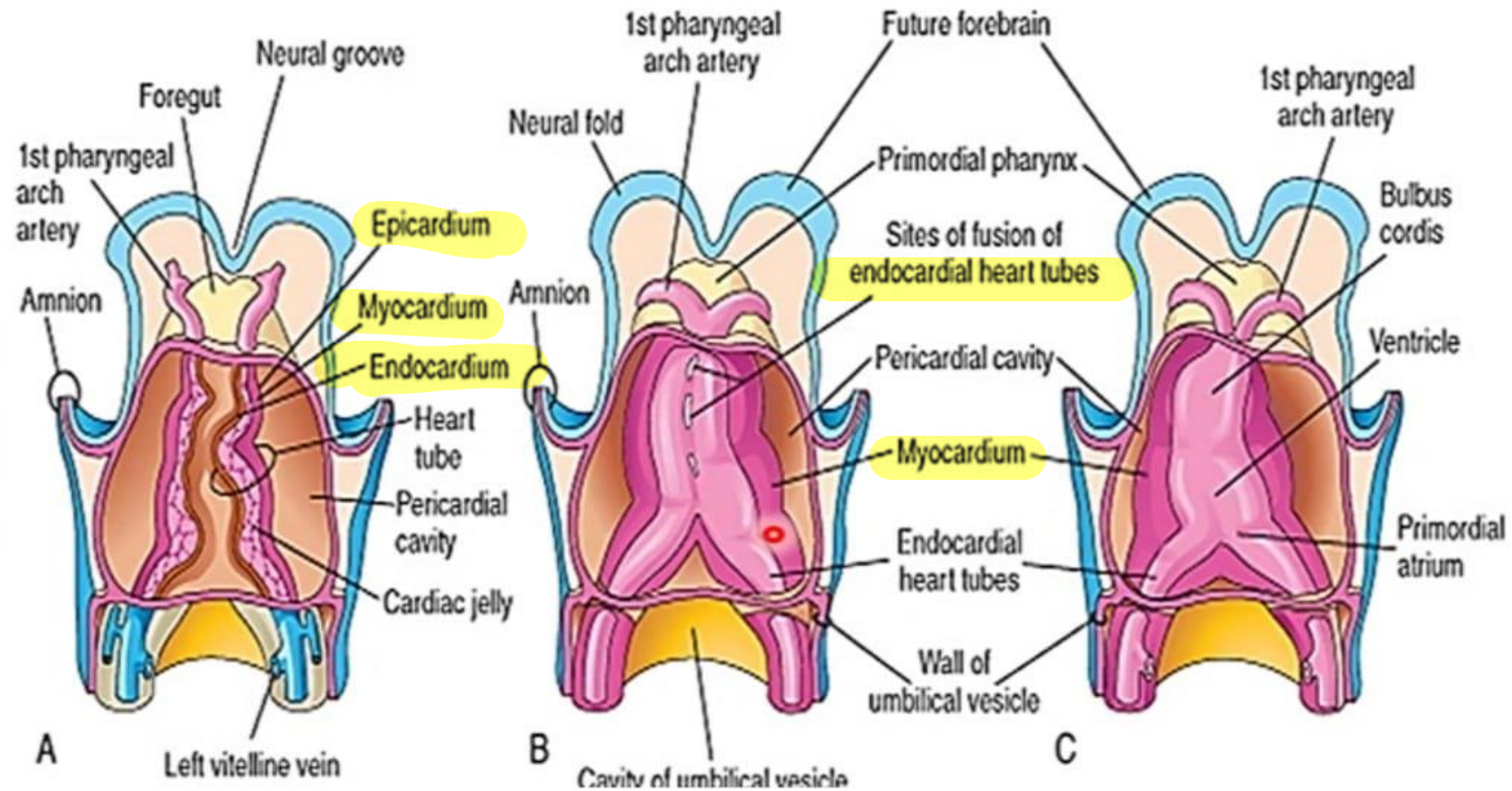


N.B: - The **3** sources are **mesodermal**.

- Endocardial tube will form the **endocardium**.

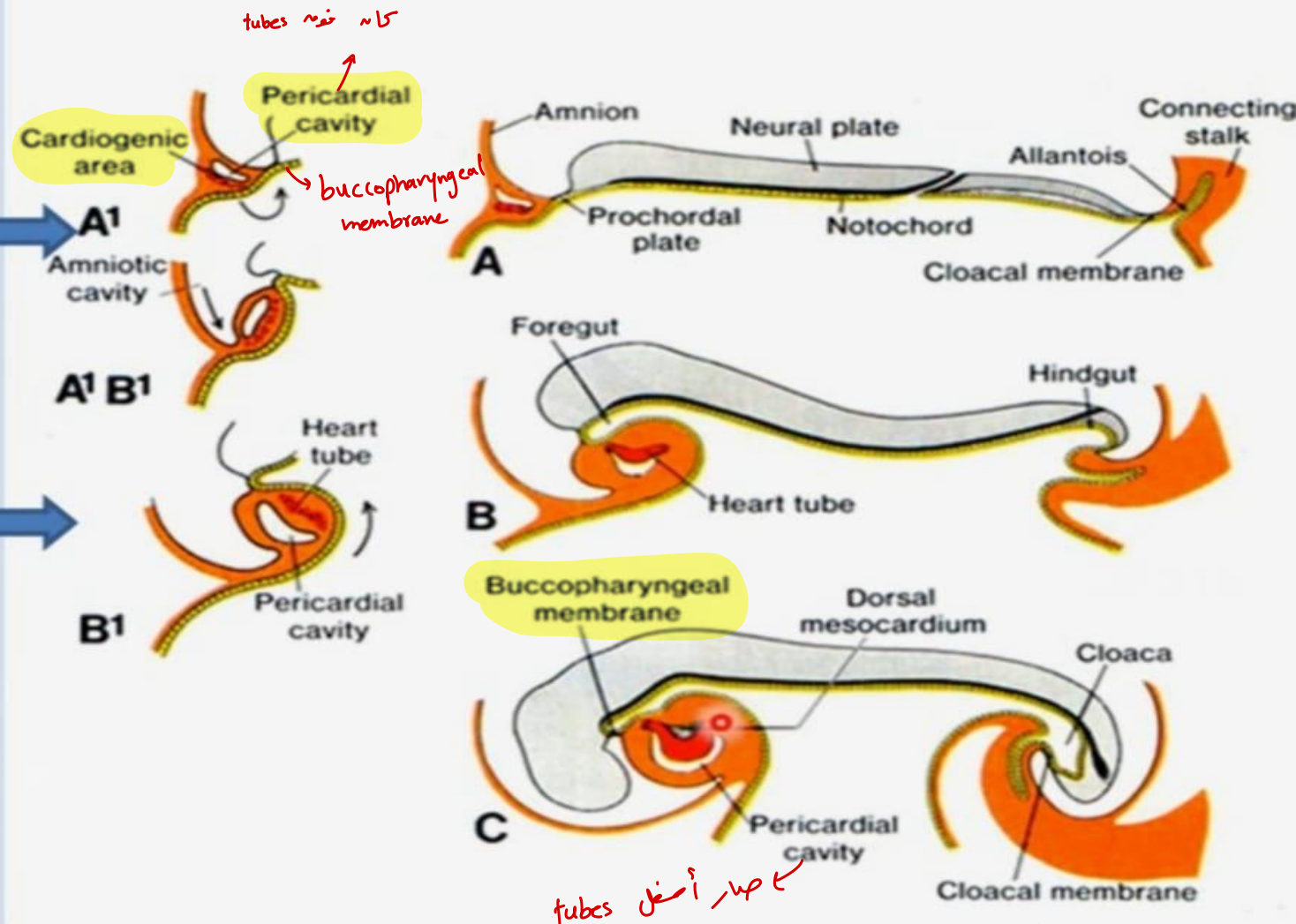
- Myo-epicardial mantle will form the **myocardium**.

- Visceral layer of the pericardial sac will form the **epicardium**.



Let's remember results of the head folding:

- Notice the arrangement of the **septum transversum**, **pericardial cavity**, and the **oral membrane**:
- Before folding: **septum transversum** is **cranial**, the **oral membrane** is **caudal**, and the **pericardial cavity** lies **between** them.
- After the cranial fold: the **oral membrane** **becomes cranial**, the **septum transversum** **becomes caudal**, and the **pericardial cavity** lies **between** them (**caudal to oral membrane**, and **cranial to septum transversum**).



FOUR CHANGES OF THE HEART TUBE

نقسمها إلى 4 خطوات لتسهيل دراستها
ملكنه في الحقيقة كل هذه الخطوات
تحدث في نفس الوقت

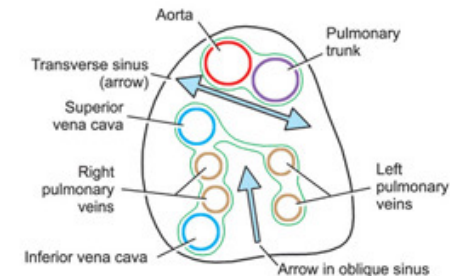
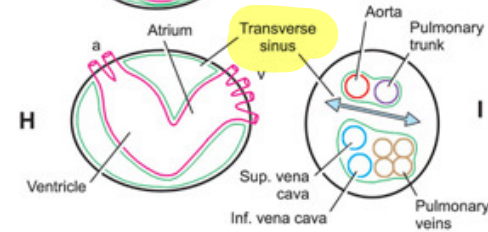
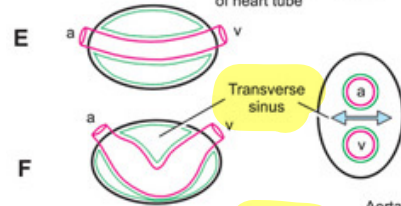
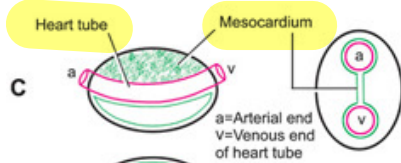
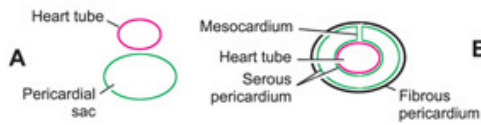
1. INVAGINATION OF THE TUBE INTO PERICARDIAL SAC

The pericardial sac has two layers:

- ← ملصقة للقلب The visceral layer: it lines the heart and it will form the epicardium
- ← غشاء ملصقة للقلب The parietal layer: it lines the fibrous pericardium

A region of the dorsal mesoderm is absorbed ,so the transverse sinus is formed
between the arterial and venous parts of the tube after bending





pericardium لاینفک heart tube / دایره
heart رح یصل جزء نه mesoderm فیه
↓

سیخنی درین

transverse sinus
↳ between Arterial
and Venous part
of heart
after bending

← لو وضعت ایچی ورا Aorta
رح نلاتی جیب هو Transverse sinus

2. APPEARANCE OF FIVE CHAMBERS

They are arranged in craniocaudal direction as :

تتكوّن بالترتيب

1. The truncus arteriosus (the arterial side)
2. The bulbus cordis
3. The primitive ventricle
4. The primitive atrium
5. The sinus venosus end(the venous side)

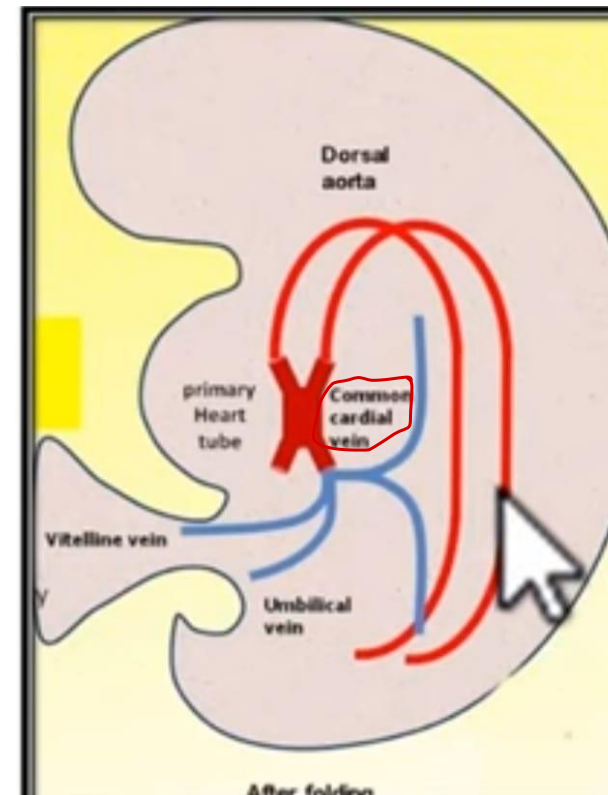
The blood enters from the venous end to the arterial end

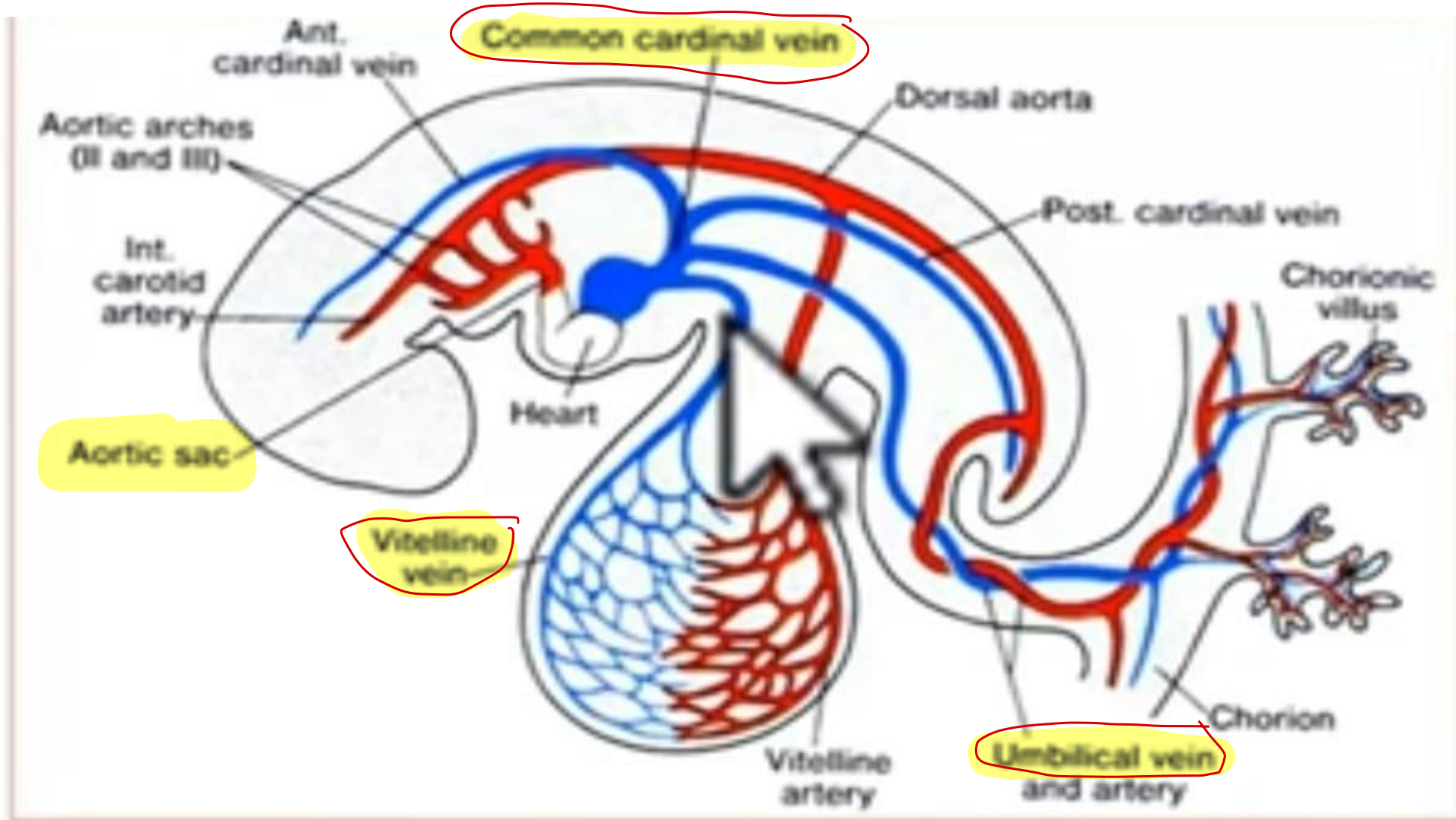


- ❑ The bulbus cordis and the ventricle are the first to appear
- ❑ Then a constriction appears between the atrium and ventricle which will form atrioventricular canal.
elongate and form

- ❑ The venous end has 2 horns
- ❑ Each horn receives 3 veins:
 1. Vitelline vein from the yolk sac *كاس*
 2. Umbilical vein from umbilical cord
 3. Cardinal vein from the body wall

superior inferior
مترابعا في
common Cardial vein





vitelline, umbilical and embryonic circulation.



The arterial end forms the aortic sac which has 2 horns

Note:

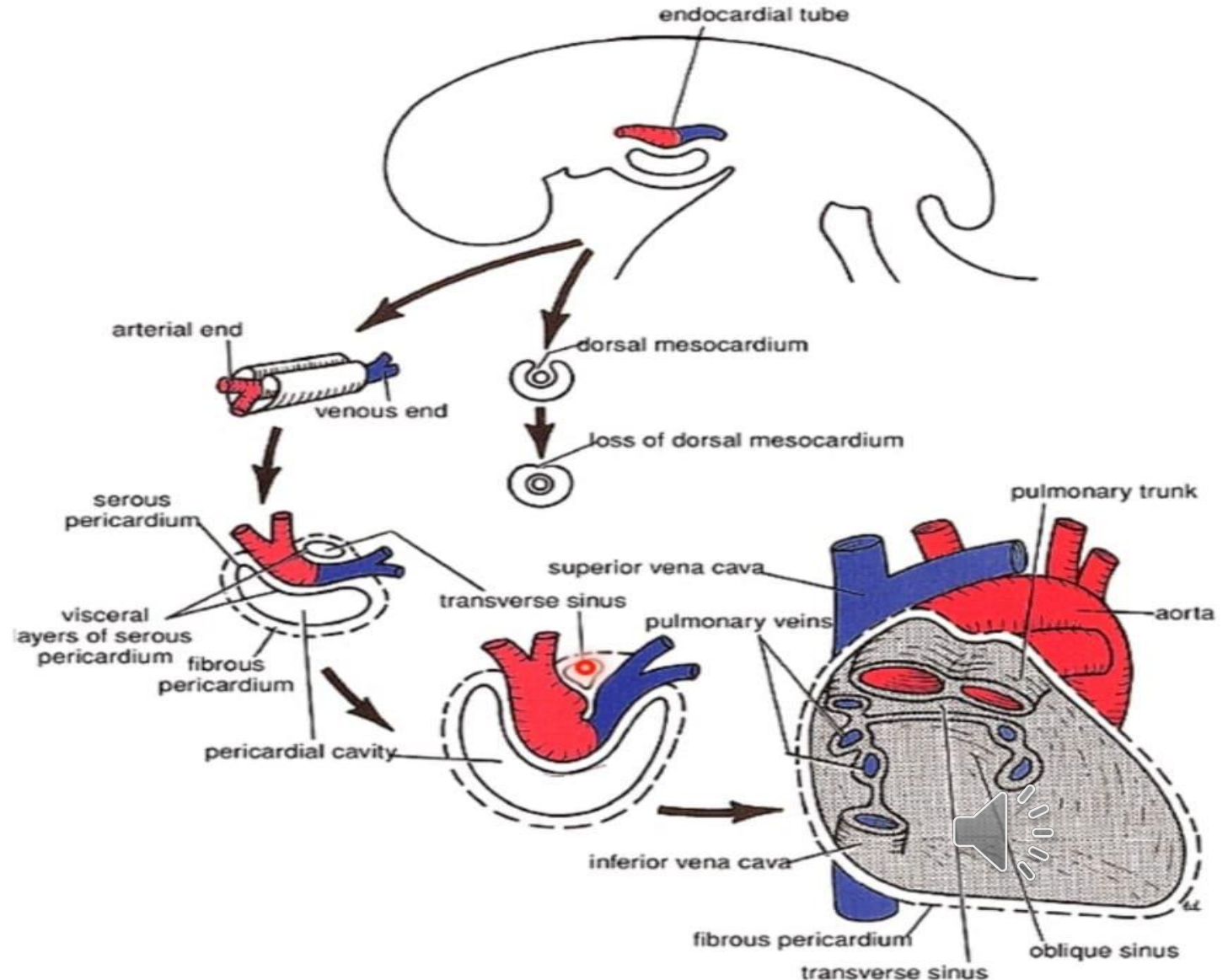
Sinus venosus is the last to form



The 4 changes of the heart tube

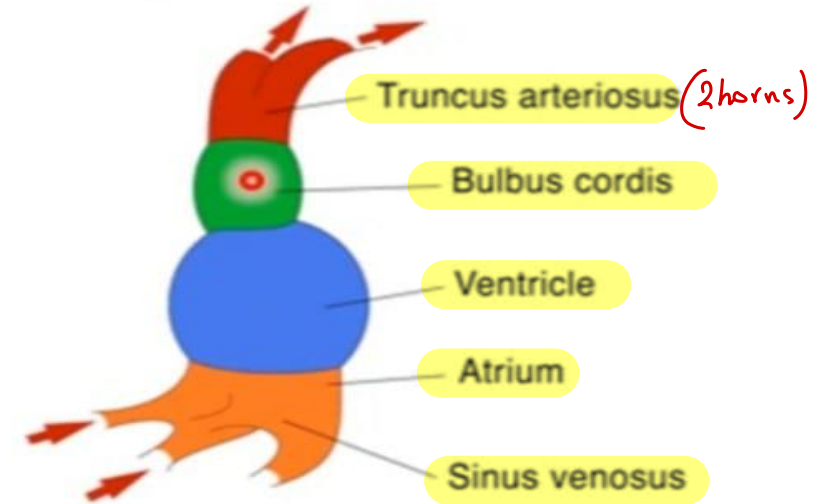
1) invasion of the pericardial sac:

- It occurs from the **dorsal aspect** of the pericardial sac.
- **Dorsal mesocardium** is a double layer fold **attached to the dorsum of the tube**.
- **Dorsal mesocardium** will be **absorbed** forming the **transverse sinus** of the **pericardium** between the **arterial** and **venous ends** of the tube.

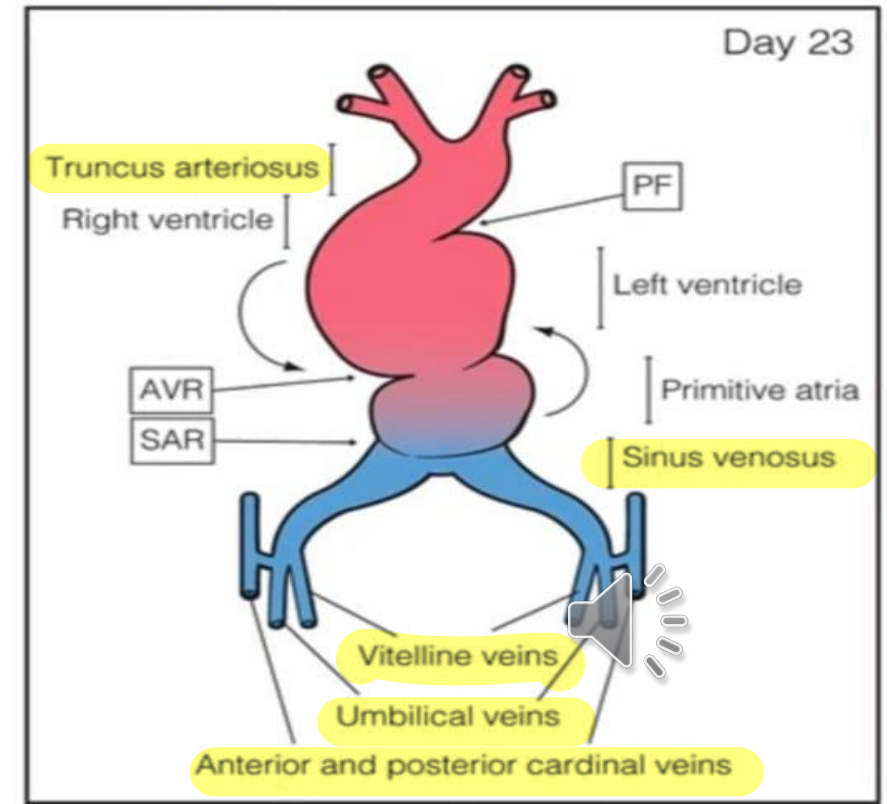


The 4 changes of the heart tube (cont.)

- 2) appearance of five chambers:
- They are **5 dilatations** separated by constrictions.
- They are **arranged** in **cranio-caudal** direction as: **truncus arteriosus (arterial end)**, **bulbus cordis**, **ventricle**, **atrium**, and **sinus venosus (venous end)**.



- N.B:**
- **Bulbus cordis** and **ventricle** are the **first** to appear, while **sinus venosus** is the **last**.
 - **Constriction between atrium and ventricle** is **elongated (atrioventricular canal)**.
 - The **venous end** has **2 horns**, each horn receives **3 veins (vitelline, umbilical, and common cardinal)**.
 - The **arterial end** forms the **aortic sac** with **2 horns (see later)**.



3. ELONGATION AND BENDING

أي حصة تطول وأطرافها حبيطة ← أكيد رج تنسني على نفس

bending to the right ← لوصار

dextrocardia ← عكس
(Apex of heart to the right side)

- This bending is to the left → Apex of heart to left side
- Bending occurs because of elongation while the two ends are fixed
- Elongation occurs in different rates → atrium صغائر، ventricle متلا
- Bulboventricular loop takes **U shape** ← عينا first bending جس ← رج يعلوا عكس
bulbs cordis & ventricle
- The bulbus is now to the right of the ventricle



← ينحبوا للداخل

- The atrium and sinus venosus are drawn inside

- The atrium becomes posterior to the bulboventricular structure ,so the tube takes

S shape

← مع الجنب

- The atrium expands to form right and left atrium

← يبدأها
Posterior



The 4 changes of the heart tube (cont.)

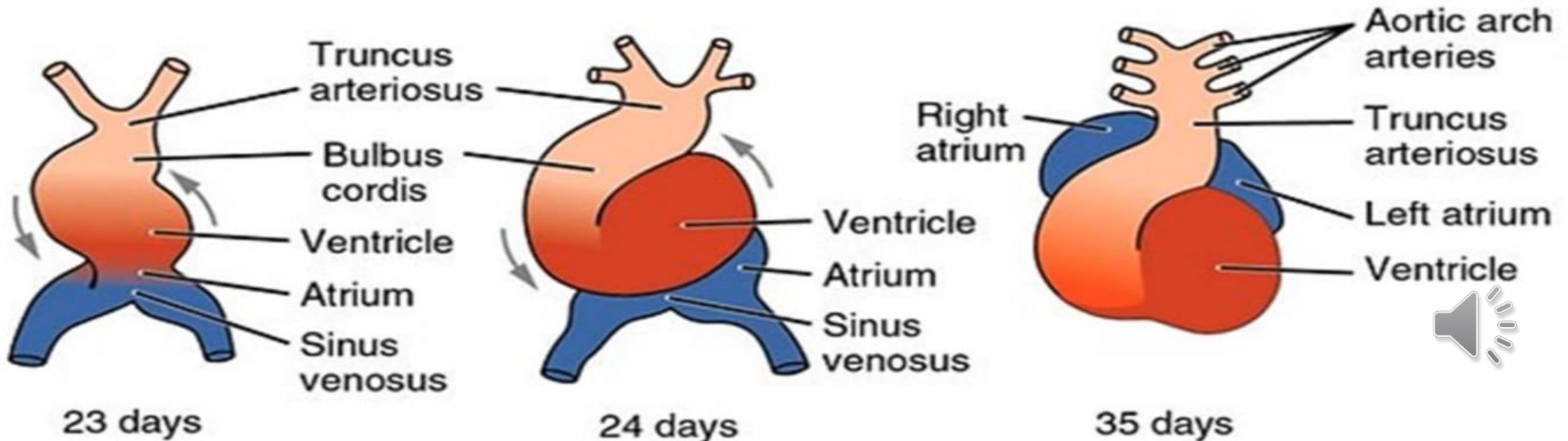
3) elongation + bending:

The heart tube will have to bend because:

- A) It **elongates** while **its ends** are **fixed**.
- B) **Its growth** is **more** and **faster** than the **growth** of **pericardial** sac.
- C) **Growth** of its **parts** is **disproportionate**.

Notice the following:

- **U-shaped** bulbo-ventricular loop.
- Then **S-shaped** heart tube.
- **Bulbus cordis** will **shift** to the **right** of ventricle.
- **Atrium** will **expand** transversely.



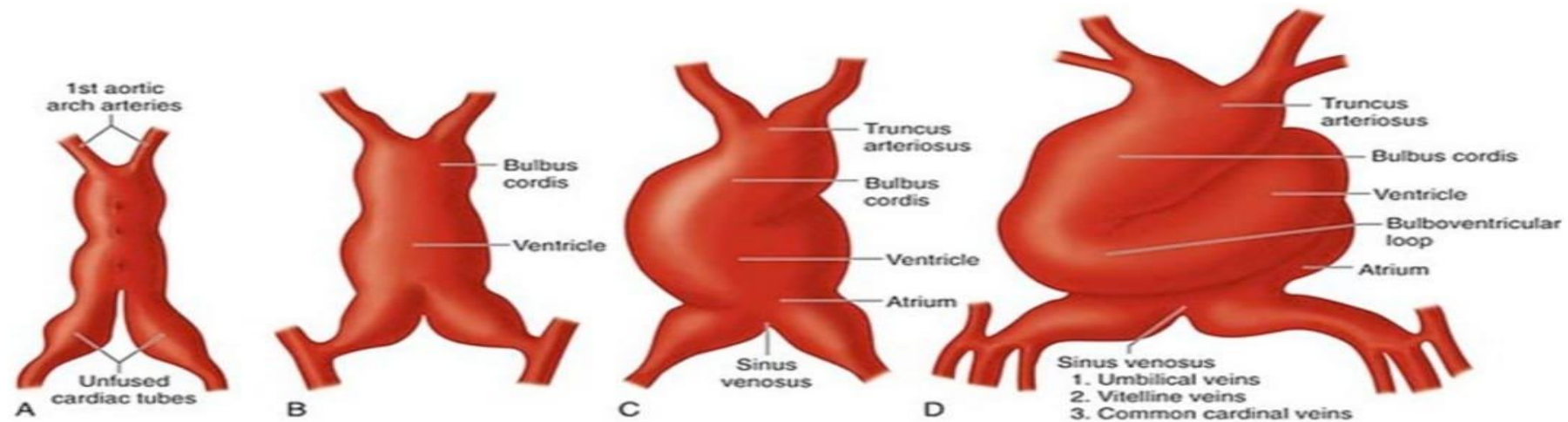
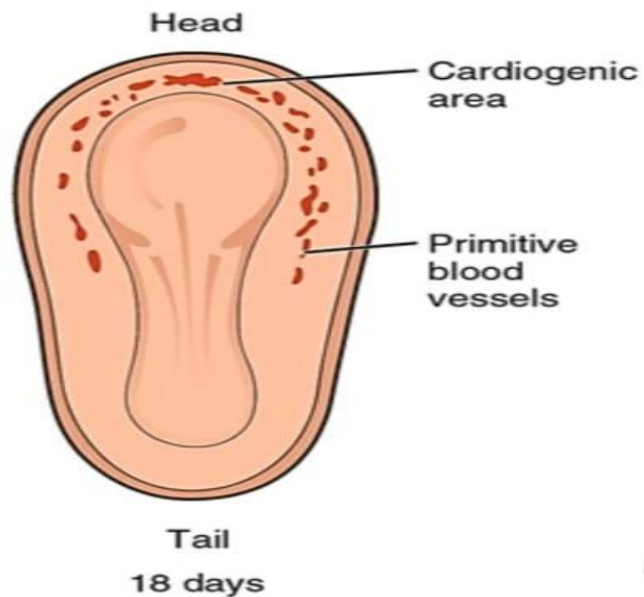
4. CAUDAL MIGRATION

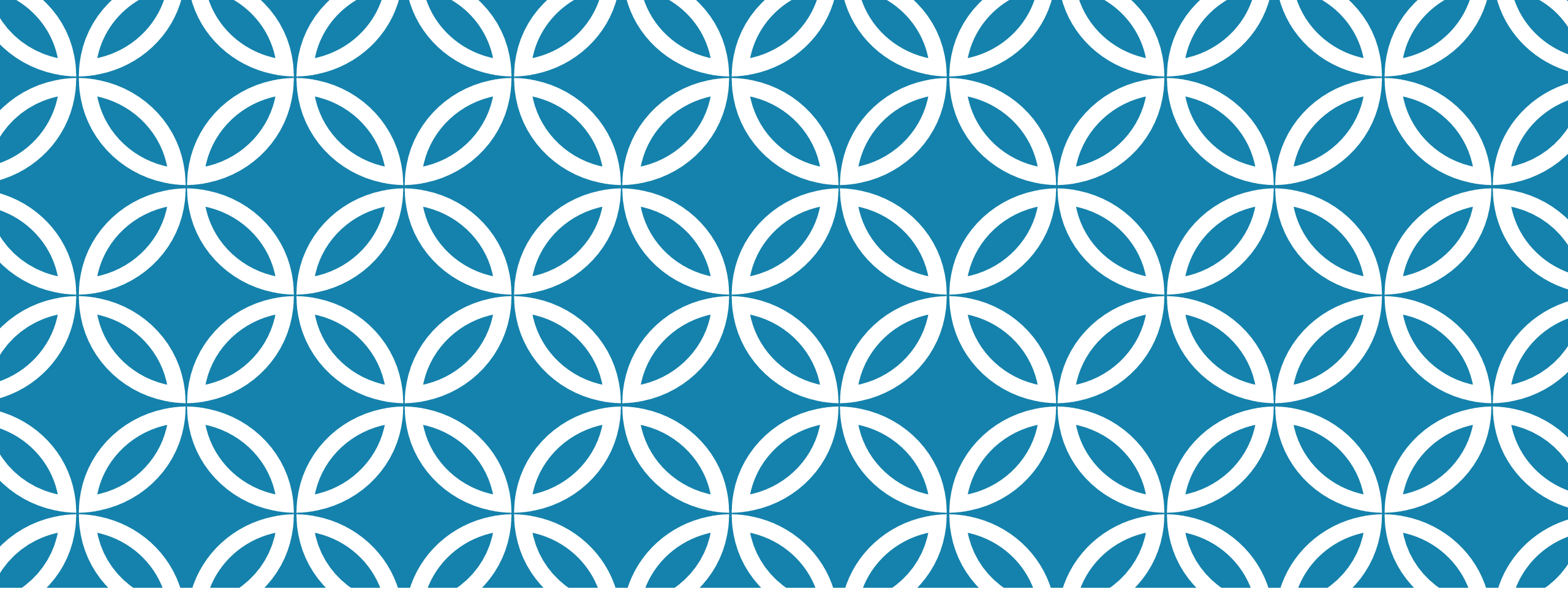
The heart and pericardium migrates caudally from the cranial region (third to fourth) somite to the region of (17th to 20th) somites



The 4 changes of the heart tube (cont.)

- 4) caudal migration:
- The heart and pericardium **migrates** caudally from **3rd-4th somites** to **17th-20th somites**.





CARDIAC EMBRYOLOGY 2

SINUS VENOSUS

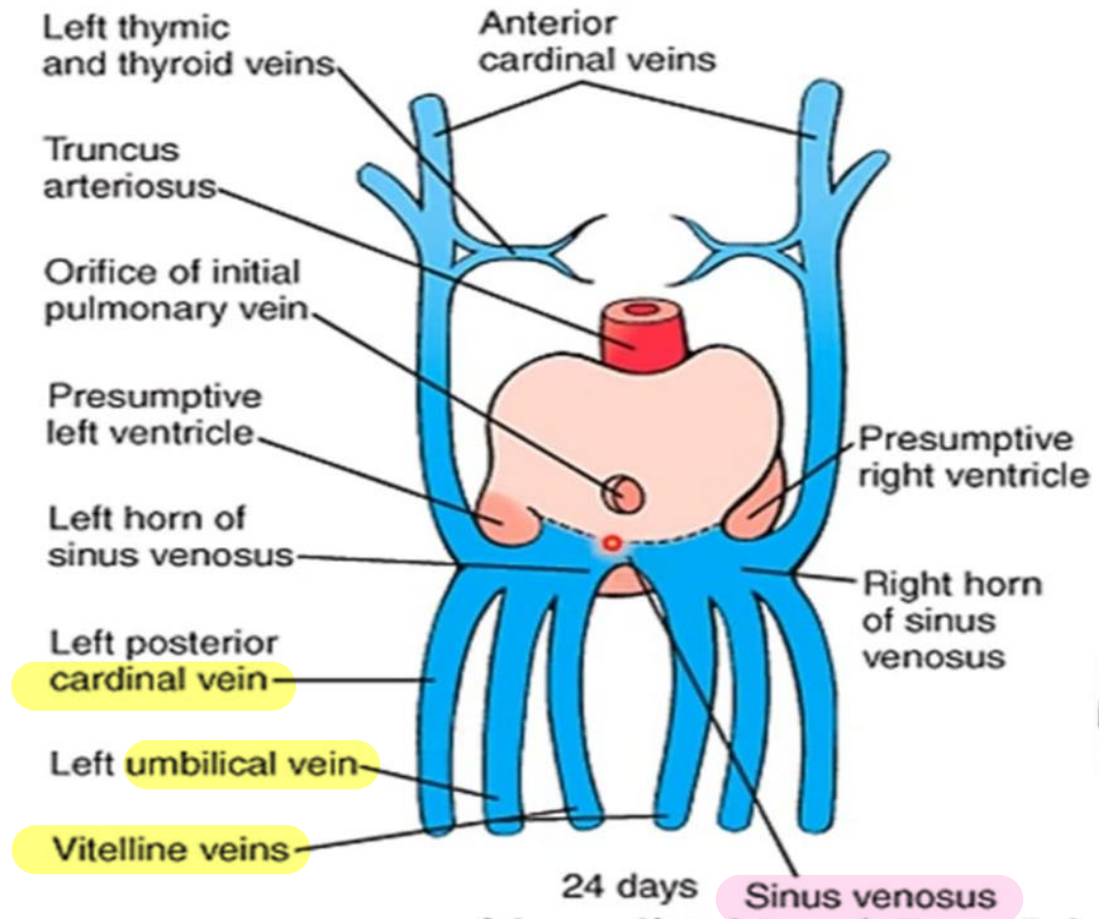
Dr. Sawsan
S. Shurub

- In the middle of the fourth week, the sinus venosus receives venous blood from the right and left sinus horns .
→ Chamber 5 (الغرفة 5)
- Each horn receives blood from three important veins:
 - (1) the vitelline or the omphalomesenteric vein,
 - (2) the umbilical vein,
 - (3) the common cardinal vein



The sinus venosus

- 1) At first: sinus venosus **opens in the center of back of the primitive atrium**, and has **2 horns**, each horn receives **3 veins**:
- Common cardinal (from the body wall).
- Umbilical (from the placenta).
- Vitelline (from the yolk sac).



- At first, communication between the sinus and the atrium is wide.

Soon, however, the entrance of the sinus shifts to the right

في الدم تقصه نخلة من اليسار إلى اليمين ← بالمنطقة الميسرة يحرك والسيار يضم إلى التالي فتتجه sinoatrial opening إلى ناحية اليمين
بعدما كانت في المنتصف

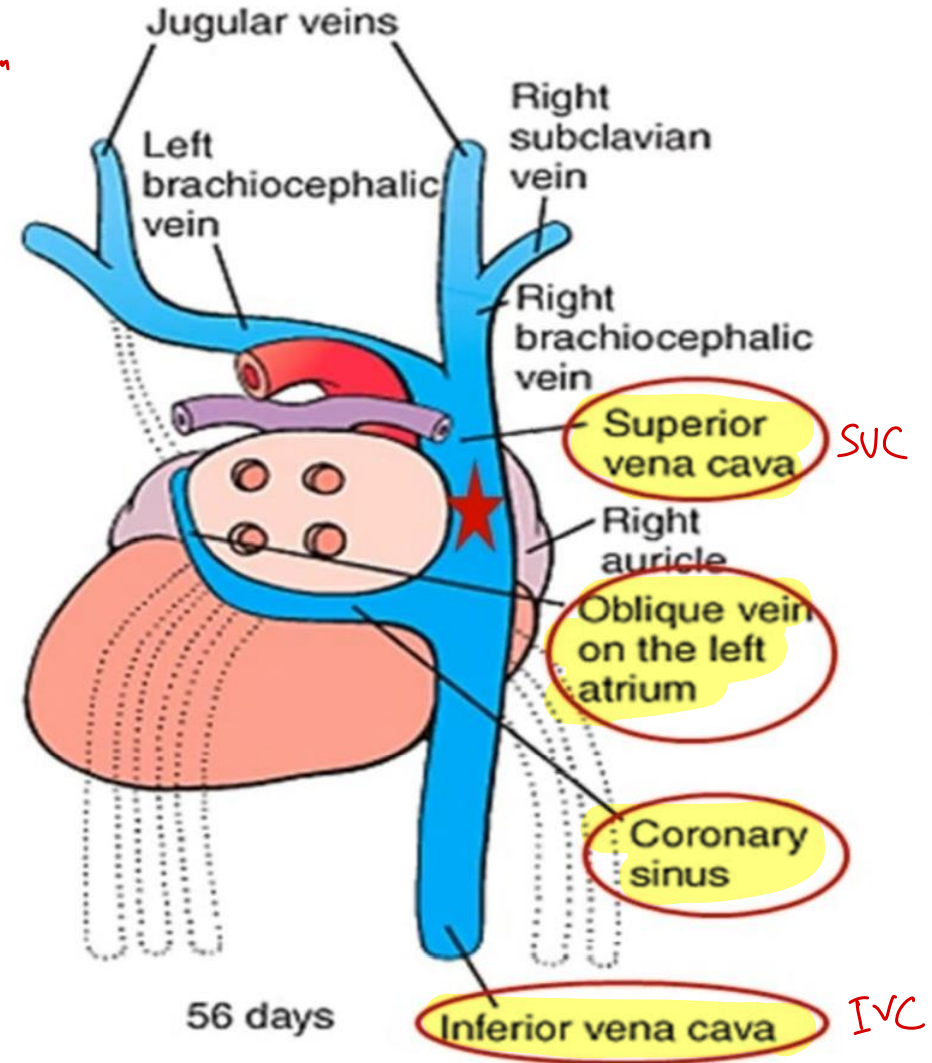
- This shift is caused primarily by left-to-right shunts of blood, which occur in the venous system during the fourth and fifth weeks of development



- **4) So the fate will be:**

- The **right horn** = **posterior smooth part of right atrium**.
- The **right common cardinal vein** = **lower part of SVC**.
- The **right vitelline vein** = **opening of the IVC**.
- The **diminished body** and **left horn** = **coronary sinus**.
- The **left common cardinal vein** = **oblique vein of left atrium**.

Right atrium
 ↳ smooth
 ↳ Right horn
 ↳ fused to right atrium
 ↳ rough
 ↳ primitive atrium (البطين)



- With obliteration of the left umbilical vein and the left vitelline vein during the fifth week, the left sinus horn rapidly loses its importance.
- When the left common cardinal vein is obliterated at 10 weeks, all that remains of the left sinus horn is the oblique vein of the left atrium and the coronary sinus



- As a result of left-to-right shunts of blood, the right sinus horn and veins enlarge greatly.
- The right horn, which now forms the only communication between the original sinus venosus and the atrium, is incorporated into the right atrium to form the smooth-walled part of the right atrium



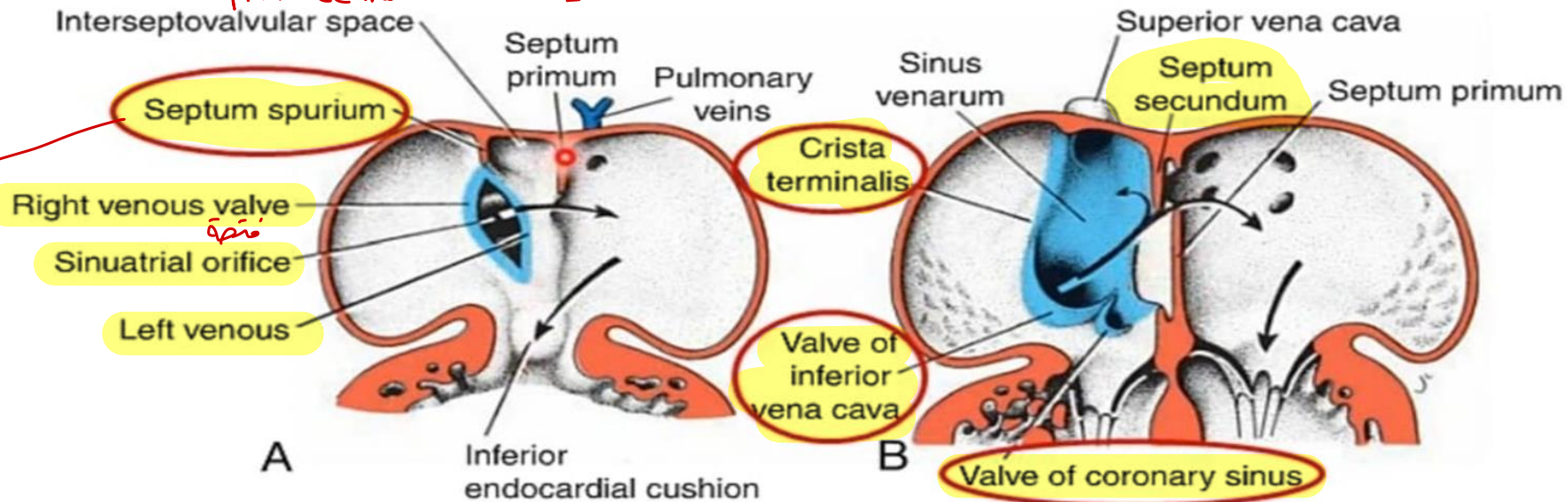
- 4) what about the opening of the sinus into the right atrium:
- It is **vertical slit** like opening.
- Its **right and left edges** are called (**sino-atrial valves**).
- They **fuse superiorly** forming (**septum spurium**).
- **Upper part of the right valve** = **crista terminalis**.
- **Lower part of right valve** = **valve of both IVC and coronary sinus**.
- **Left valve** = **part of inter-atrial septum**.

right
sinoatrial
valve

Left
sinoatrial
valve

ناقص من الزمان
Left & Right
sinoatrial
valves

سائد في
septum secundum



- Its entrance, the **sinuatrial orifice**, is flanked on each side by a valvular fold, the right and left venous valves .
- ^{من خلفه} Dorsocranially, the valves fuse, forming a ridge known as the septum spurium .
- Initially the valves are large, but when the right sinus horn is incorporated into the wall of the atrium, the left venous valve and the septum spurium fuse with the developing atrial septum.

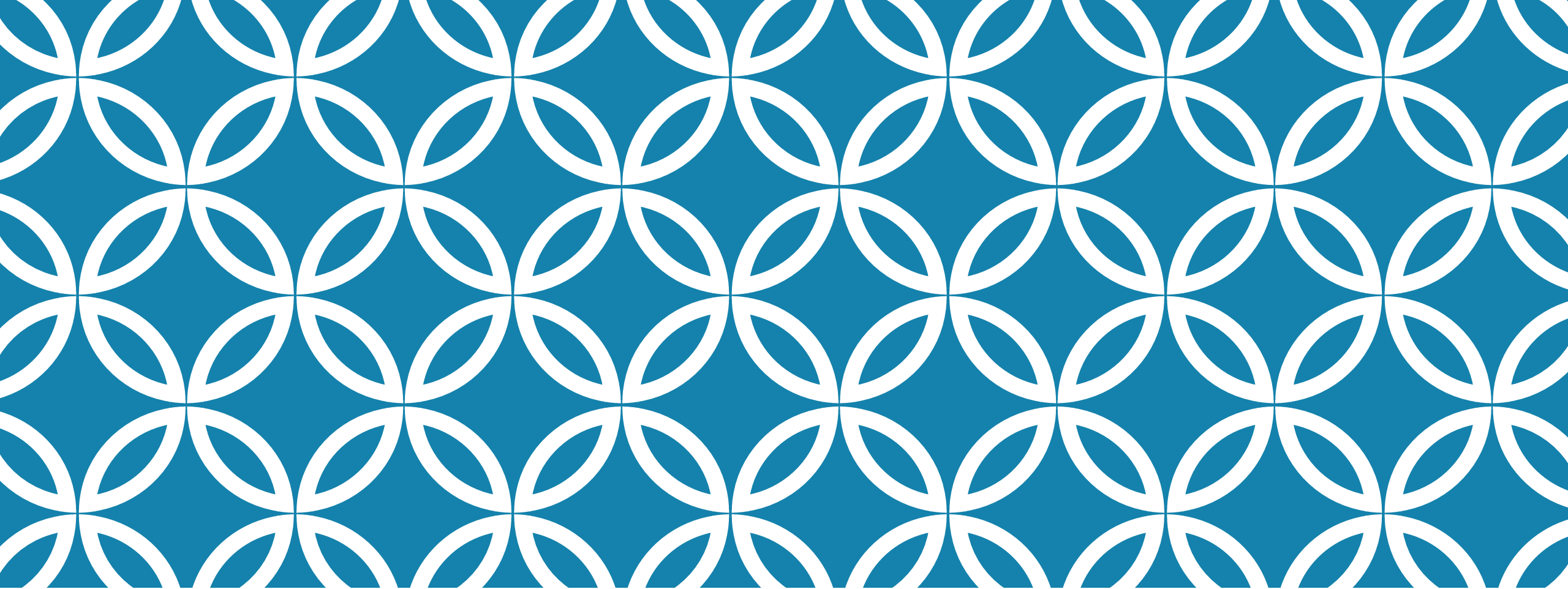
→ Septum secundum
inter-atrial septum



- The superior portion of the right venous valve forms the crista terminalis.
- The inferior portion develops into two parts:
 - (1) the valve of the inferior vena cava
 - (2) the valve of the coronary sinus .
- **The crista terminalis** forms the dividing line between the original trabeculated part of the right atrium and the smooth-walled part (sinus venarum), which originates from the right sinus horn.

primitive
atrium





CARDIAC EMBRYOLOGY 3

ATRIA AND INTERATRIAL SEPTUM

*Dr. Sawsan
S. Shurrab*

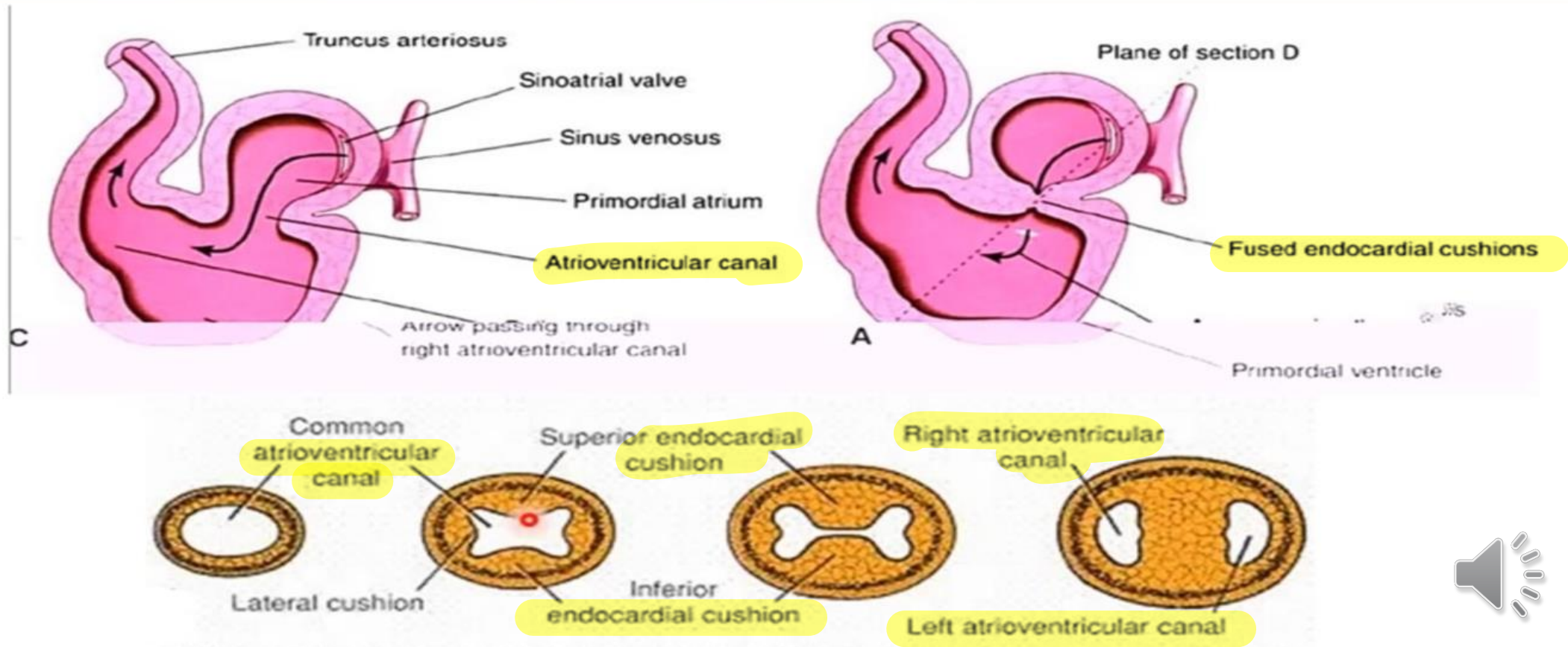
SEPTUM FORMATION IN THE ATRIOVENTRICULAR CANAL

- At the end of the fourth week, two mesenchymal cushions, the atrioventricular endocardial cushions, appear at the anterior and posterior borders of the atrioventricular canal



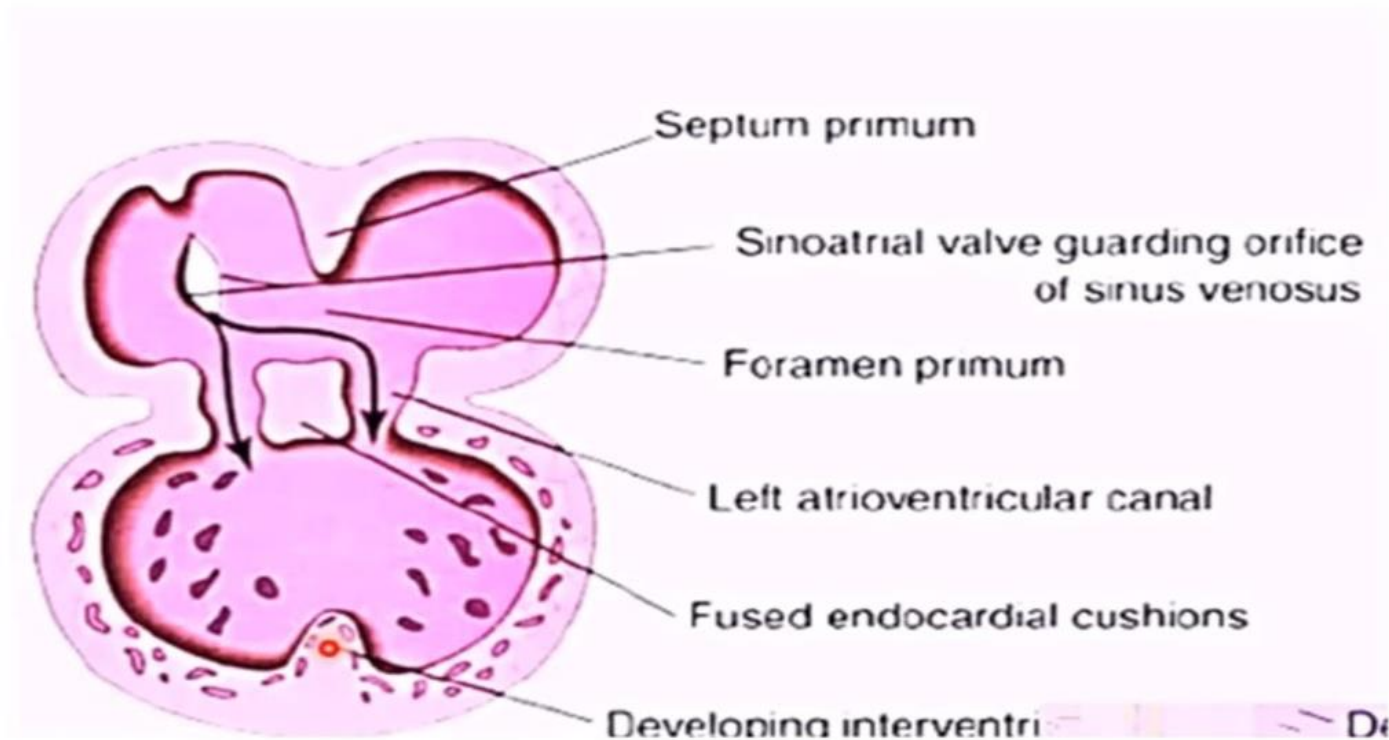
The atrioventricular canal

- It is the elongated constriction between primitive atrium and ventricle:
- 2 endocardial cushions (**ventral** and **dorsal**) appear, and **fuse** together forming **septum intermedium**.
- **Septum intermedium divides** the **canal** into **right** and **left** parts.



inter atrial septum ← راجع يشارك في تصنيع atrium side
 و septum الموجود في مواجهة Ventricle ← يشارك في تصنيع
 endocardial cushions ← التي اندمجت في القلب
 2 sides
 باتجاه Atrium
 باتجاه Ventricle
 inter Ventricular Septum (جزئين)
 membranous (جزء خشن)
 muscular (جزء ناعم)

- **Ventricular side of each part proliferates forming cusps of A-V valves.**
- **The atrial side of each part shares in formation of the corresponding atrium.**
- **The septum intermedium shares in forming the membranous part of IV (Inter ventricular septum).**



نرى ما في endocardial cushions (anterior & posterior) واندمجت
 أنفذاً يربط right & left cushions (الجابنين) ← راجع يشارك
 mitral + Tricuspid valve (left) (right)
 (cusps of A-V valves)



- In addition to the anterior and posterior endocardial cushions, the two lateral atrioventricular cushions appear on the right and left borders of the canal .
- The anterior and posterior cushions, in the meantime, project further into the lumen and fuse, resulting in a complete division of the canal into right and left atrioventricular orifices by the end of the fifth week
- Because of their key location, abnormalities in endocardial cushion formation may cause cardiac malformations, including atrial and ventricular septal defects (VSDs) .

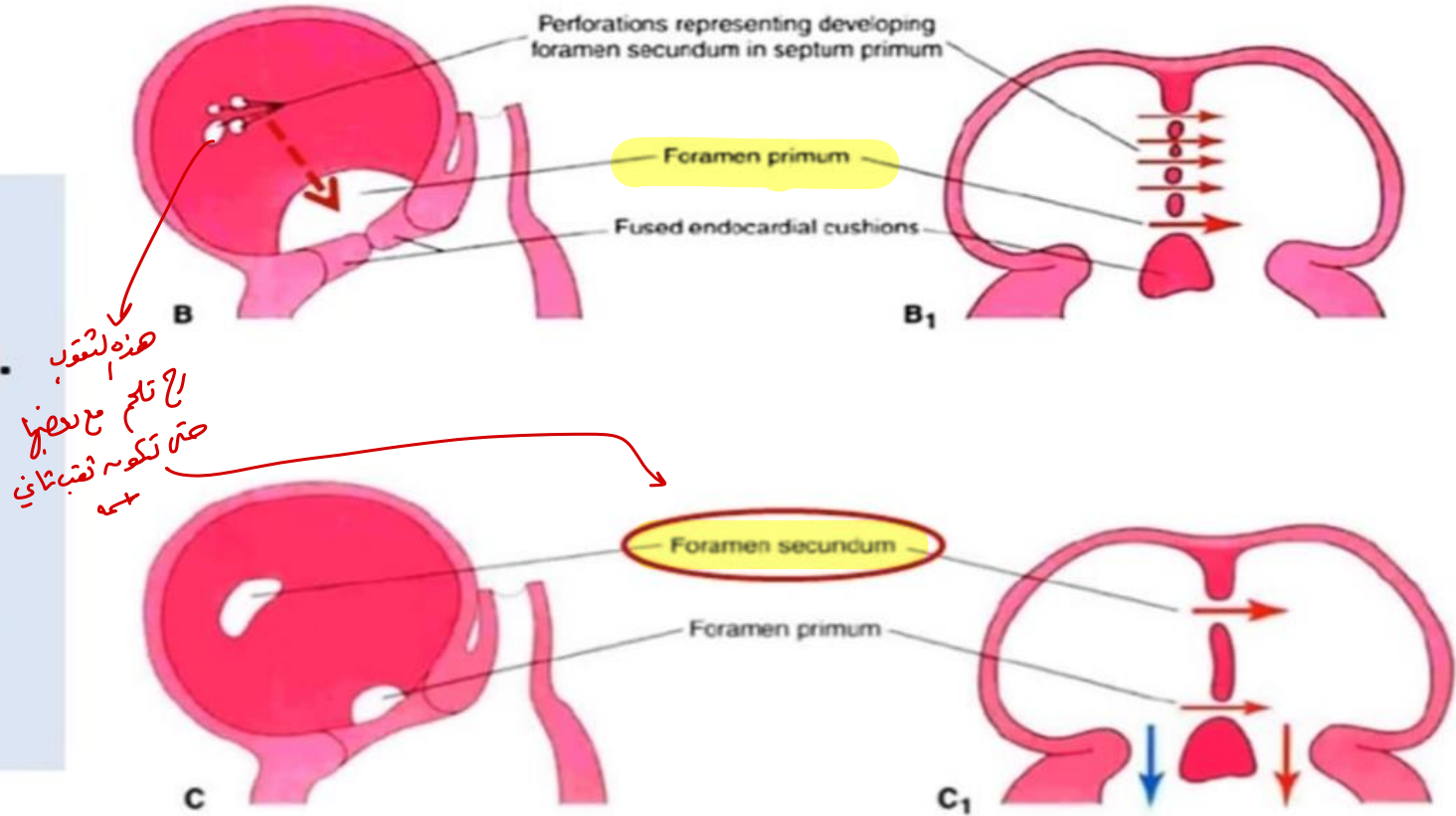


SEPTUM FORMATION IN THE COMMON ATRIUM

- At the end of the fourth week, a sickle-shaped crest grows from the roof of the common atrium into the lumen.
- This crest is the first portion of the **septum primum** ^{الحاجز الأولي}
- The two limbs ^{لغزاة على شكل منجل} of this septum extend toward the endocardial cushions ^{septum intermedium} in the atrioventricular canal.
- The opening between the lower rim of the septum primum and the endocardial cushions is the **ostium primum**



- Foramen **primum** progressively becomes smaller, and finally closed.
- Just before its complete closure, septum **primum** ruptures in its center forming another foramen (foramen **secundum**).



- With further development, extensions of the superior and inferior endocardial cushions grow along the edge of the septum primum, closing the ostium primum.
- Before closure is complete, however, cell death produces perforations in the upper portion of the septum primum.
- Coalescence of these perforations forms the **ostium secundum**, ensuring free blood flow from the right to the left primitive atrium.

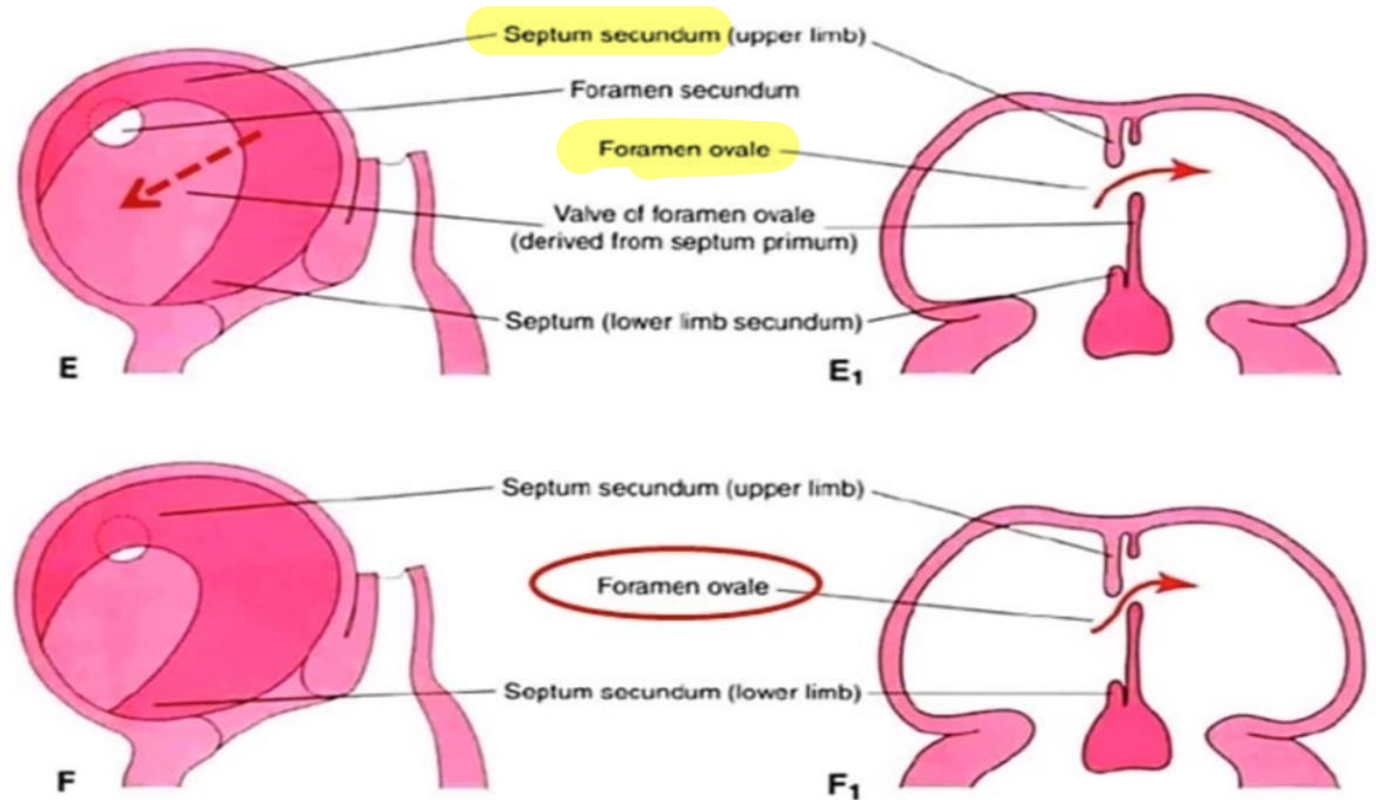


- When the lumen of the right atrium expands as a result of incorporation of the sinus horn, a new crescent-shaped fold appears.
- This new fold, the **septum secundum**, never forms a complete partition in the atrial cavity .
- Its anterior limb extends downward to the septum in the atrioventricular canal.

أمالياتي
 عن لاصم
 oval shape
 تارك اكنه
 Foramen ovale
 بنسبه



- **B) Septum secundum:**
- It is also **crescentic** membrane. It develops just to the **right** side of septum primum.
- The **opening below** it is the **foramen ovale**.
- It **reaches** the **ventral endocardial cushion only**, and is **completed** by the **left venous valve** (see sinus venosus).



values ← ← right ← Sinoatrial Valve
 septum secundum ← ← left



- When the left venous valve and the septum spurium fuse with the right side of the septum secundum, the free concave edge of the septum secundum begins to overlap the **ostium secundum**

يفضي

Septum primum نزل من roof صير يصل لثقت ويصل
 ostium primum مع قفيل تماماً وقبل ما قفيل مع نيكه ostium secundum في هذا
 . septum primum

وبعده مع نزل كما septum secundum صير يغطي على ostium secundum
 مع نيكه ثمة
 foramen ovale .

الجزء الذي كان فيه ostium secundum كله اختفى
 septum primum وبقى الجزء الاكبر من
 أصبح valve و foramen ovale



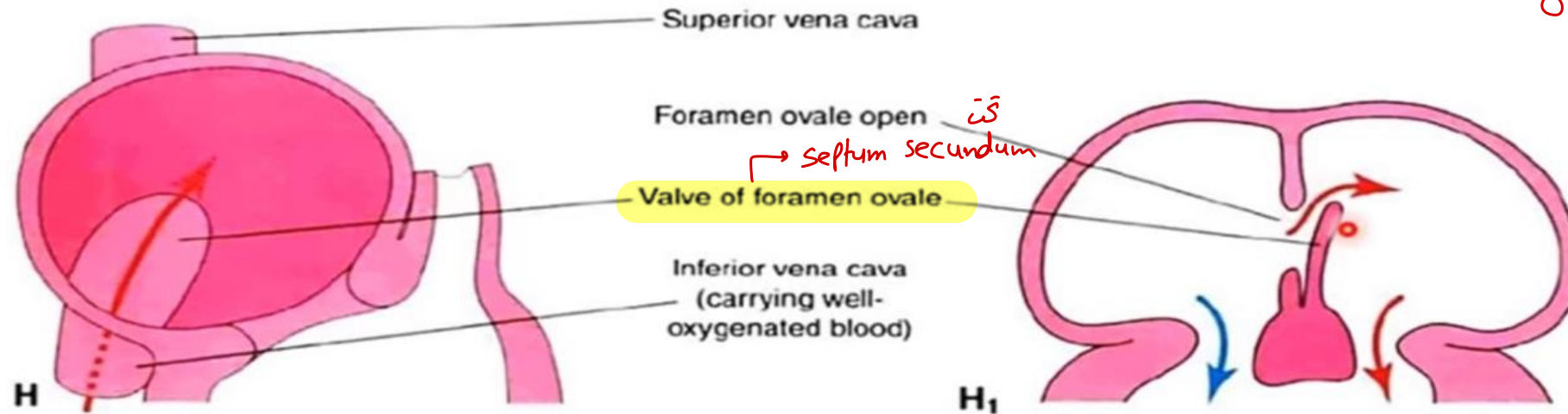
- The opening left by the septum secundum is called the oval foramen (**foramen ovale**).
- When the upper part of the septum primum gradually disappears, the remaining part becomes the valve of the oval foramen.
- The passage between the two atrial cavities consists of an obliquely elongated cleft through which blood from the right atrium flows to the left side .

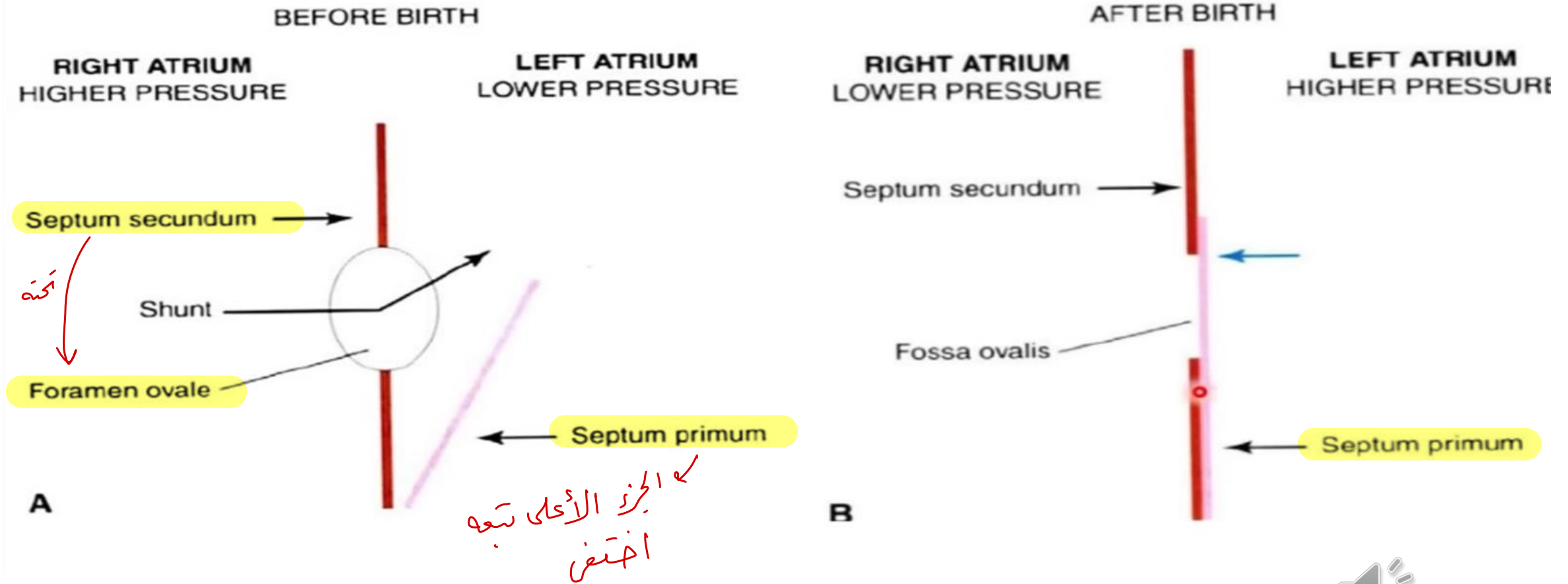


- Notice the direction of blood flow:
- It **passes** through **tortuous** course (S-shaped) from **right** to **left** atrium **through** foramen **ovale**, then foramen **secundum**.
- Notice the **valvular** action of the remaining **lower** part of **septum primum**.

ولما بدأ يرجع الدم خارج يقدر لانه Valve مغلقة

↓
valve of foramen
ovale





- After birth, when lung circulation begins and pressure in the left atrium increases, the valve of the oval foramen is ^{سكراً} pressed against the septum secundum, obliterating the foramen and separating the right and left atria.
- In about 20% of cases, fusion of the septum primum and septum secundum is incomplete, and a narrow oblique cleft remains between the two atria.
- This condition is called **probe patency of the oval foramen**; it does not allow intracardiac shunting of blood

↓
لا تفتح خطورة لأنه ما يحويه
دم كثير ينتقل عبرها.



FURTHER DIFFERENTIATION OF THE ATRIA

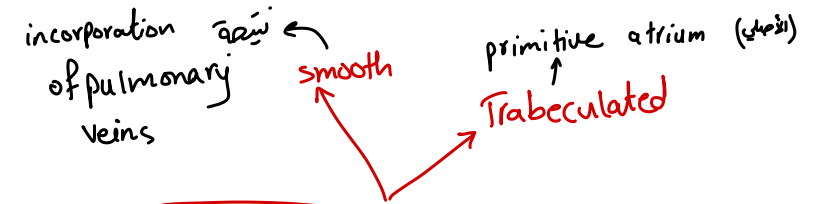
- While the primitive right atrium enlarges by incorporation of the right sinus horn, the primitive left atrium is likewise expanding.
- Initially, a single embryonic pulmonary vein develops as an outgrowth of the posterior left atrial wall, just to the left of the septum primum .



بيل vein
ديكونا ي اورد

- This vein gains connection with veins of the developing lung buds.
- During further development, the pulmonary vein and its branches are incorporated into the left atrium, forming the large smooth-walled part of the adult atrium.
- Although initially one vein enters the left atrium, ultimately, four pulmonary veins enter as the branches are incorporated into the expanding atrial wall.



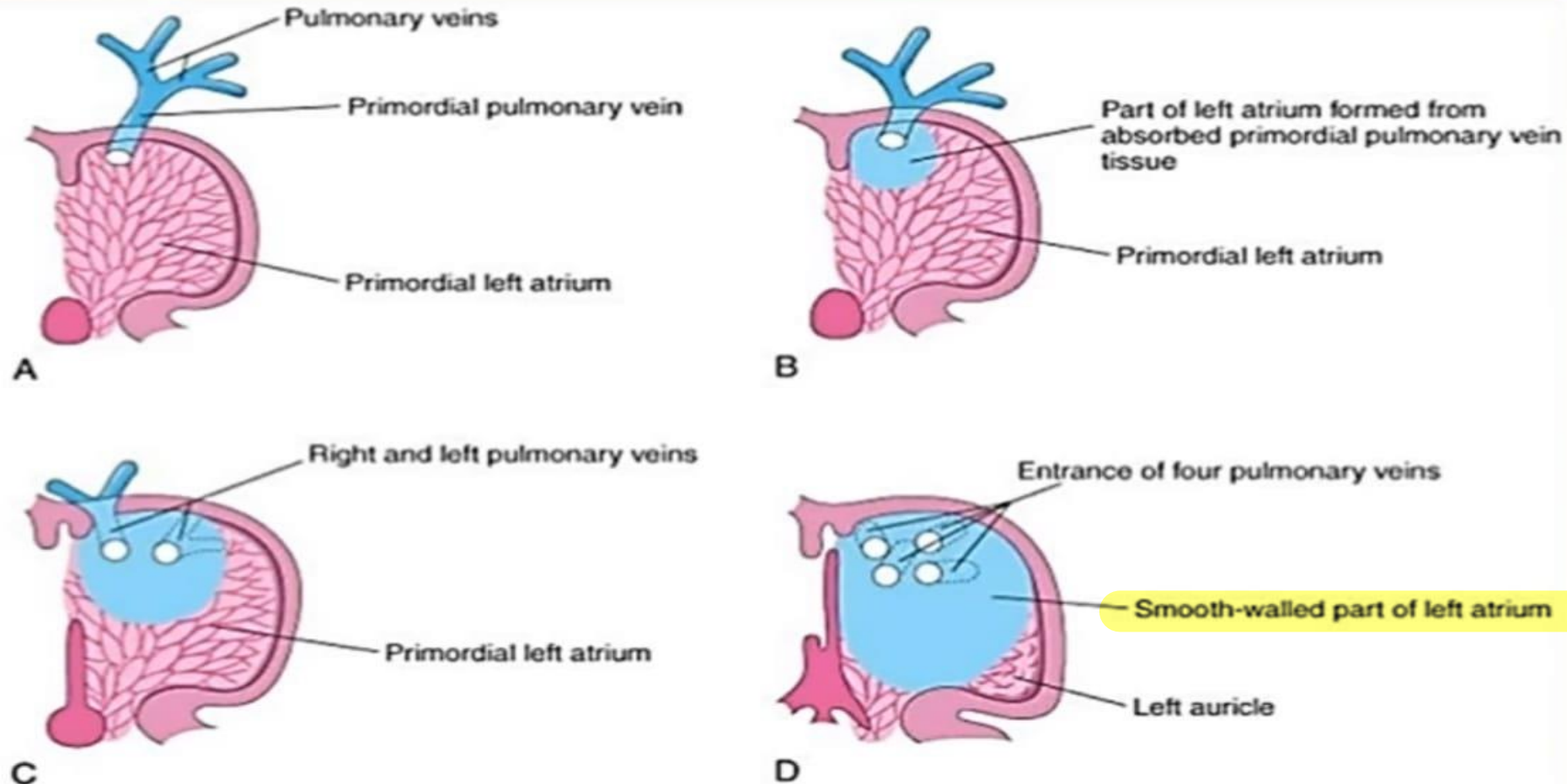


- In the fully developed heart, the original embryonic **left atrium** becomes the trabeculated atrial appendage, while the smooth walled part originates from the pulmonary veins .
- On the right side, the original embryonic right atrium becomes the trabeculated right atrial appendage containing the pectinate muscles, and the smooth-walled sinus venarum originates from the right horn of the sinus venosus

* Each atrium has smooth part and Trabeculated part

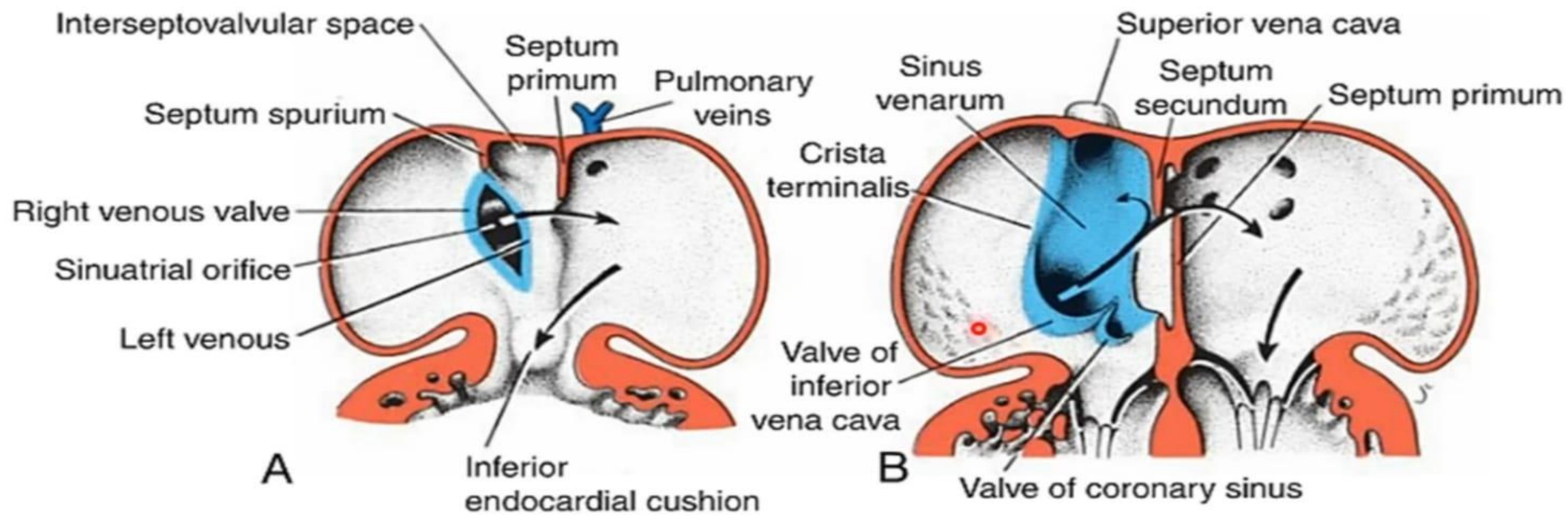


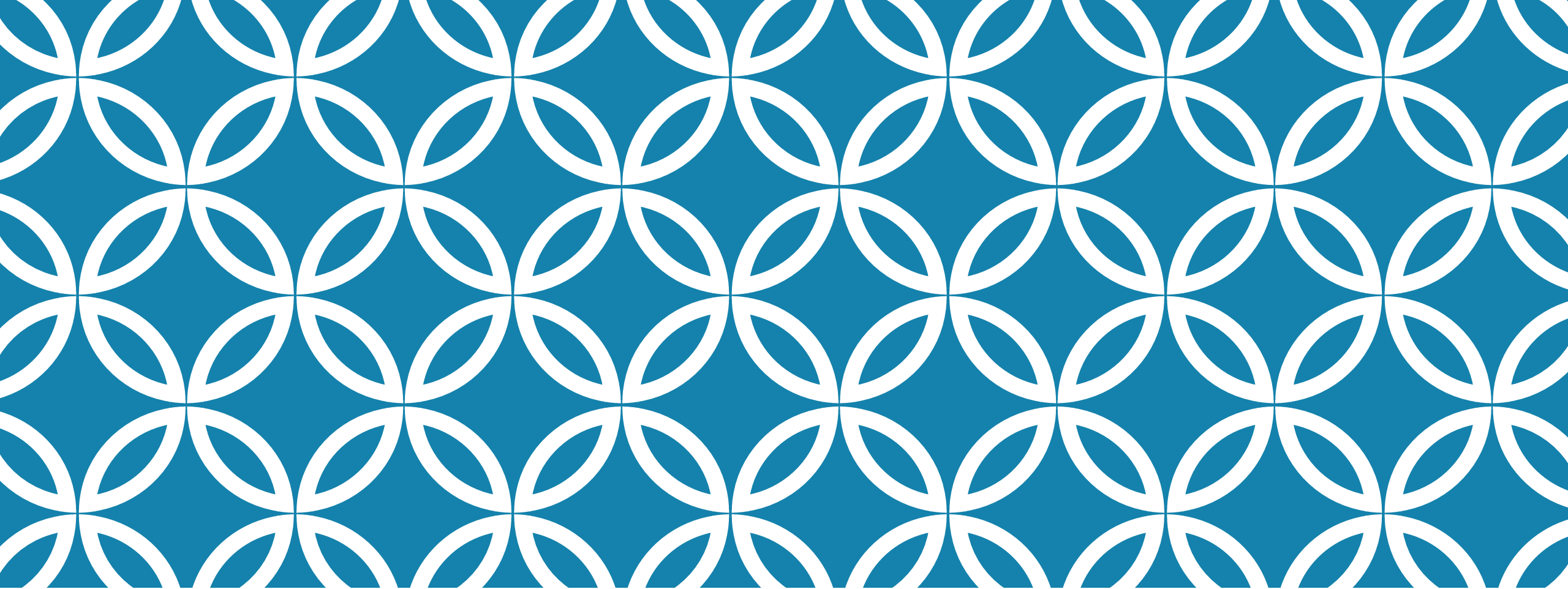
- What about the posterior wall of left atrium?
- Left atrium **receives** blood from lungs through **common pulmonary vein** (formed by **union** of **4** pulmonary **veins**).
- **Proximal** part of these **veins** is **absorbed** into the **wall** of the developing **left atrium**. That's why the **4** **pulmonary** veins open **directly** into the left atrium.



Summarize the sources of development of both atria?







CARDIAC EMBRYOLOGY 4
BULBUS CORDIS, VENTRICLES, TA

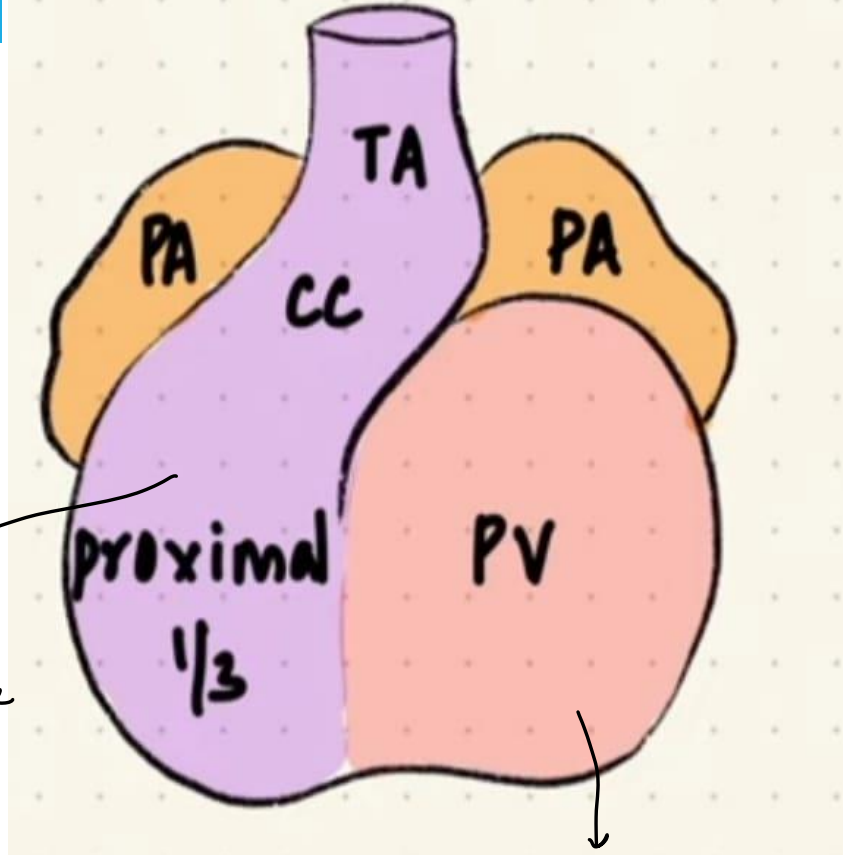
Dr. Sawsan
S. Shurub

TA → Truncus Arteriosus

CC → conus/Bulbus cordis (الزنازي)
 conus

PV → Primitive ventricle

PA → Primitive Atrium

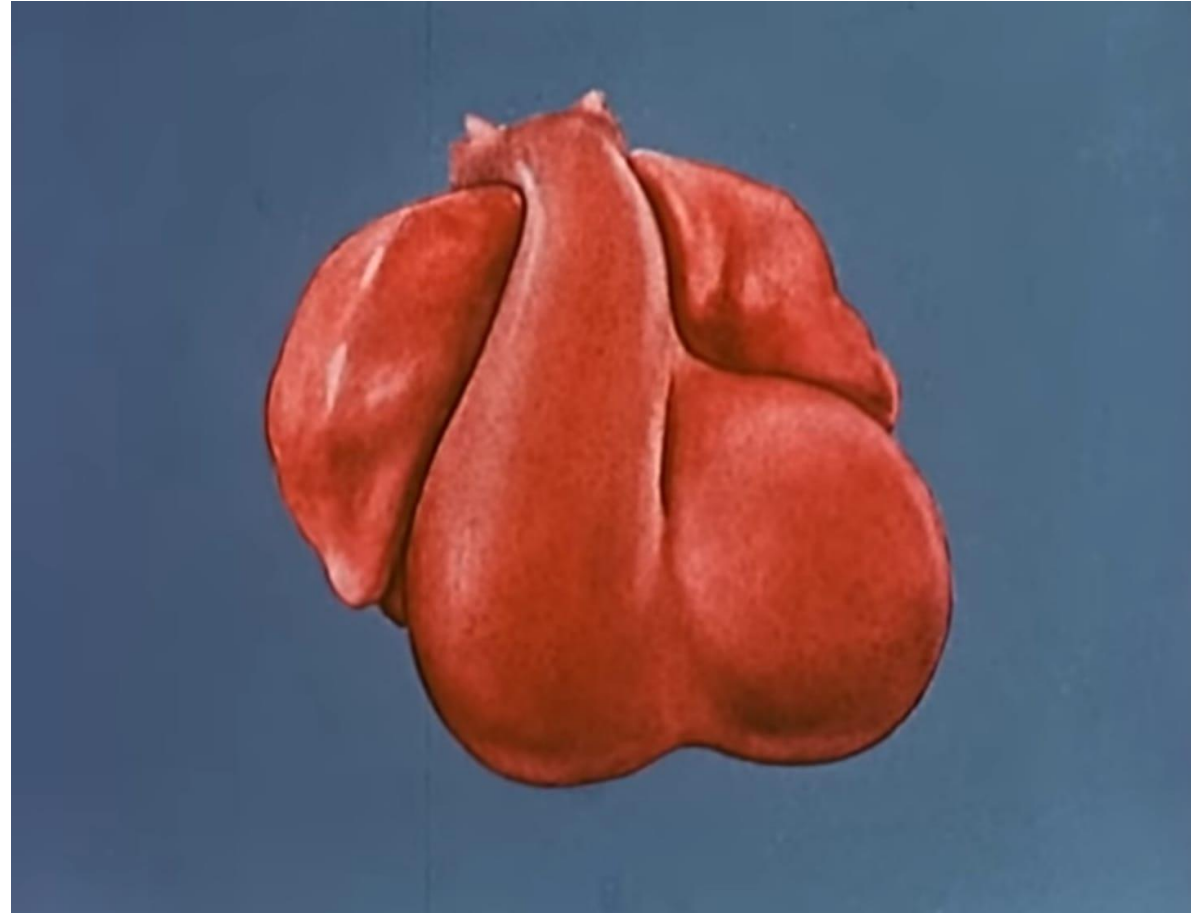


الزنازي
Right
ventricle

الزنازي
left ventricle

توضيح الصورة كيف

Bulbus cordis تم انما جراح PV
Proximal $\frac{1}{3}$ → Right ventricle



SEPTUM FORMATION IN THE ATRIOVENTRICULAR CANAL

- At the end of the fourth week, two mesenchymal cushions, the atrioventricular endocardial cushions, appear at the anterior and posterior borders of the atrioventricular canal.

2 endocardial cushion
رج يكبروا لهما ملحقوا عظاماً
و ملحقوا
↓
انفقت
atrioventricular
canal
الى
right left

- Initially, the atrioventricular canal gives access only to the primitive left ventricle and is separated from the bulbus cordis by the bulbo ventricular flange

Separation بين
bulbus cordis
& opening of A-v canal

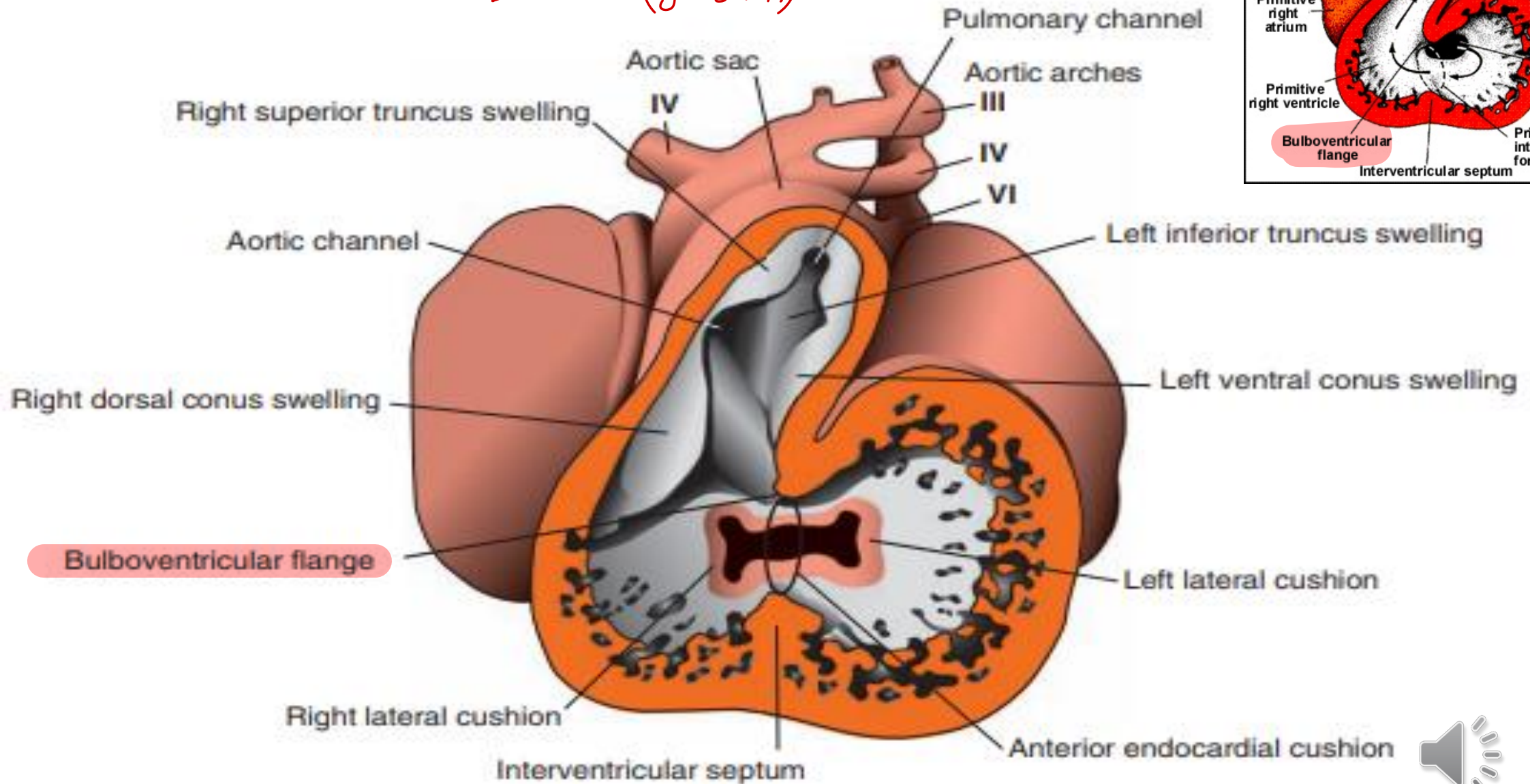
A-v canal هو : $\frac{1}{3}$ of bulbus cordis و بقية عنده القلب expansion of Atrium & ventricle - up

تصل الى both right & left ventricle



Proximal $\frac{1}{3}$ of Bulbus cordis $\rightarrow$ The Right ventricle

distal $\frac{1}{3}$ of Bulbus cordis $\rightarrow$ The $\geq$ ventricles (right & left)



- Since the atrioventricular canal enlarges to the right, blood passing through the atrioventricular orifice now has direct access to the primitive left as well as the primitive right ventricle



لأنه لابد أن يتشكل valve
right atrium & ventricle
+ left atrium & ventricle
(mitral & Tricuspid)

- In addition to the anterior and posterior endocardial cushions, the two lateral atrioventricular cushions appear on the right and left borders of the canal.
- The anterior and posterior cushions, in the meantime, project further into the lumen and fuse, resulting in a complete division of the canal into right and left atrioventricular orifices by the end of the fifth week



ATRIOVENTRICULAR VALVES (Mitral & Tricuspid valves)

- After the atrioventricular endocardial cushions fuse, each atrioventricular orifice is surrounded by local proliferations of mesenchymal tissue .

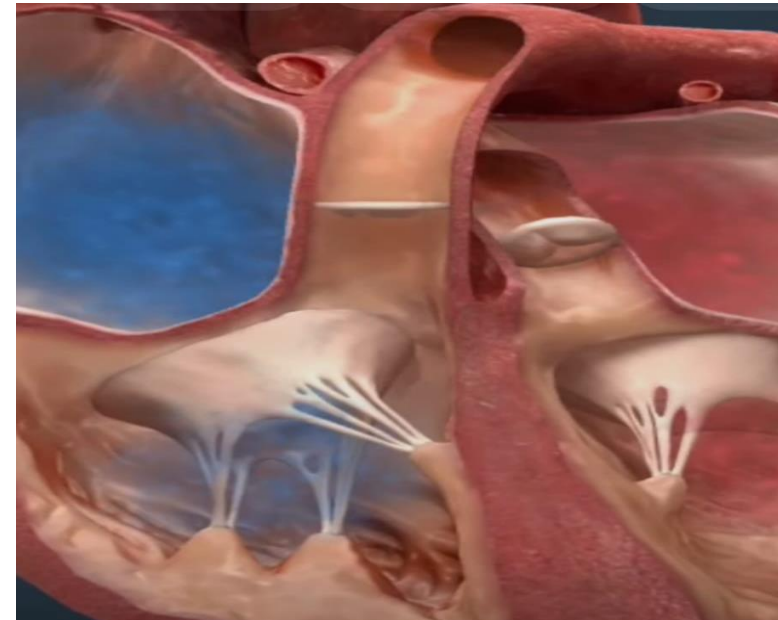
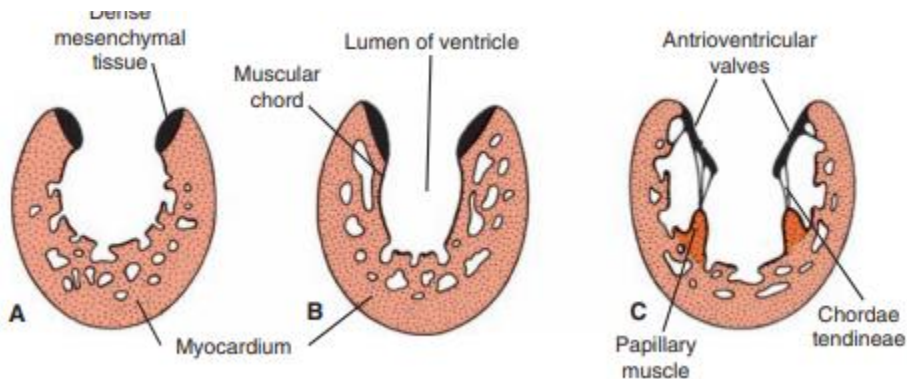
الدم سينتج خارج القلب و يحيط في كل ما يحيط في القلب
وكل ما يحيط في القلب

thinning
of tissue

- When the blood stream hollows out and thins tissue on the ventricular surface of these proliferations, valves form and remain attached to the ventricular wall by muscular cords



- Finally, muscular tissue in the cords degenerates and is replaced by dense connective tissue.
- The valves then consist of connective tissue covered by endocardium.
- They are connected to thick trabeculae in the wall of the ventricle, the papillary muscles, by means of **chordae tendineae**
- In this manner, two valve leaflets, constituting the mitral valve, form in the left atrioventricular canal, and three, constituting the tricuspid valve, form on the right



BUIBUS CORDIS

It has 2 parts:

1. The lower part: is incorporated with the primitive ventricle forming the rough part with its trabiculations

2. The upper part has a proximal and distal parts

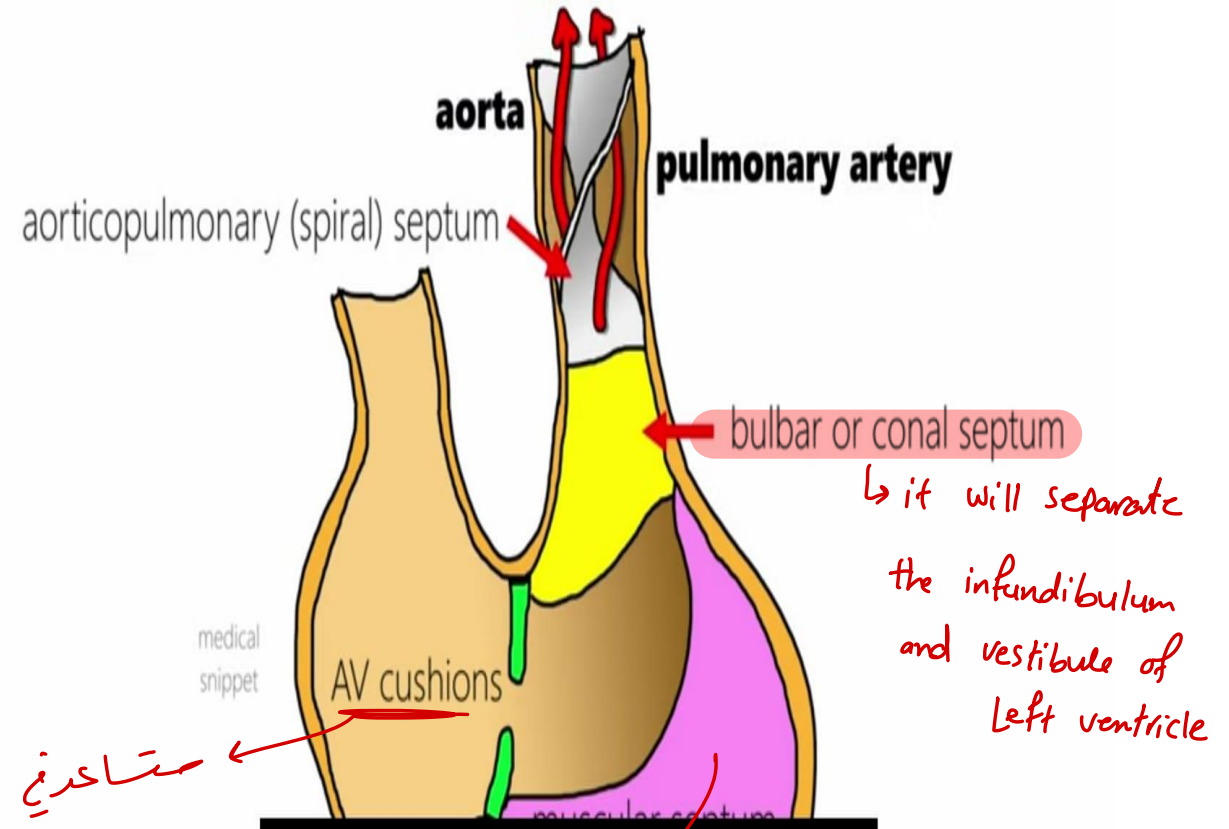
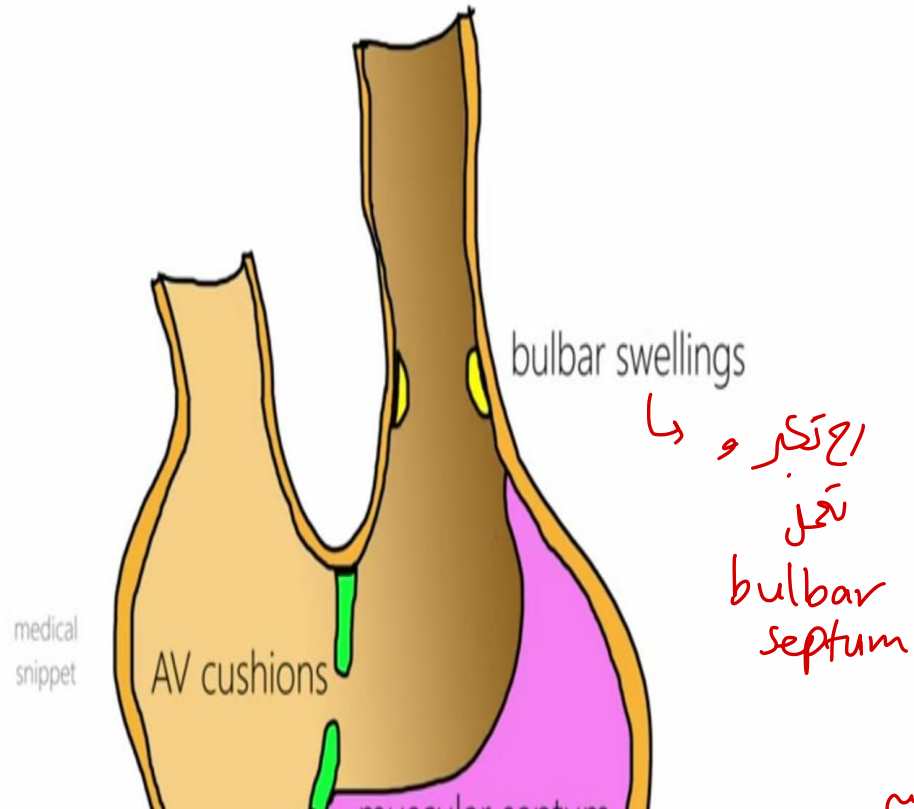
- The proximal part forms the vestibule of Lt ventricle and infundibulum of Rt ventricle which are separated by the proximal bulbar septum

- The distal part forms the pulmonary and aortic orifices

Right side

left side





الجزء الغشائي
Membranous part
of interventricular
septum

Muscular part
of interventricular
septum



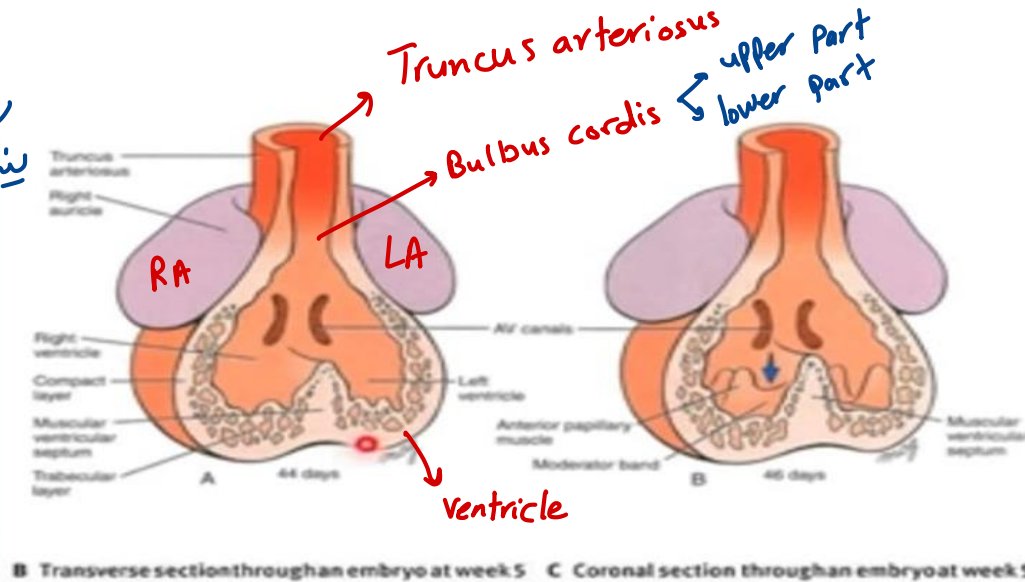
The bulbus cordis

→ inclosed relation of ventricles.

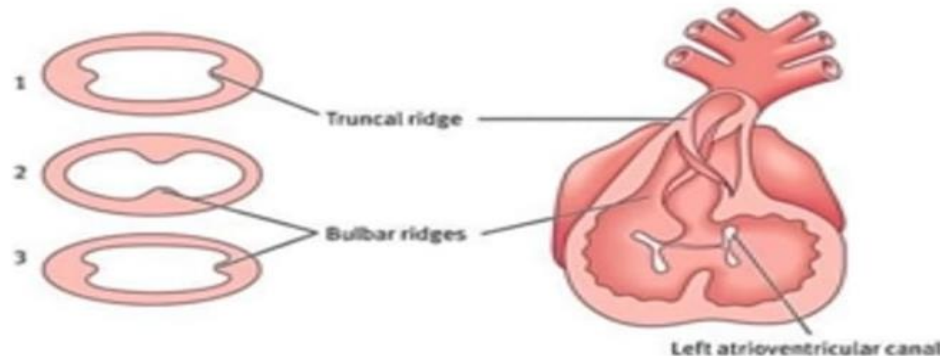
A) Lower part

- Is **incorporated** with **primitive ventricle** (bulbo-ventricular canal).
- This part forms the **rough inflowing part** of both ventricles.

Trabeculation و كحل
Spongenation و
وتقوآت .
و كحل
Trabeculae carneae of
ventricle with papillary muscle



B Transverse section through an embryo at week 5 C Coronal section through an embryo at week 5



B) The remaining upper part

- The **proximal** (near) part forms **infundibulum** of right ventricle and **vestibule** of left ventricle. This part is **divided** by **proximal bulbar septum**, which shares in **membranous part** of IV septum.
- The **distal** (far) part forms the **aortic** and **pulmonary orifices**. This part is **divided** by **distal bulbar septum**.



VENTRICLES

- The rough inflowing part of each ventricle is formed by the primitive ventricle and lower half of bulbus cordis.

- ^{من المنطقة التي صيدغ منها الدم} The smooth outflowing of each ventricle is formed by the proximal part of upper half of the bulbus cordis.

- The interventricular septum has a muscular and membranous parts

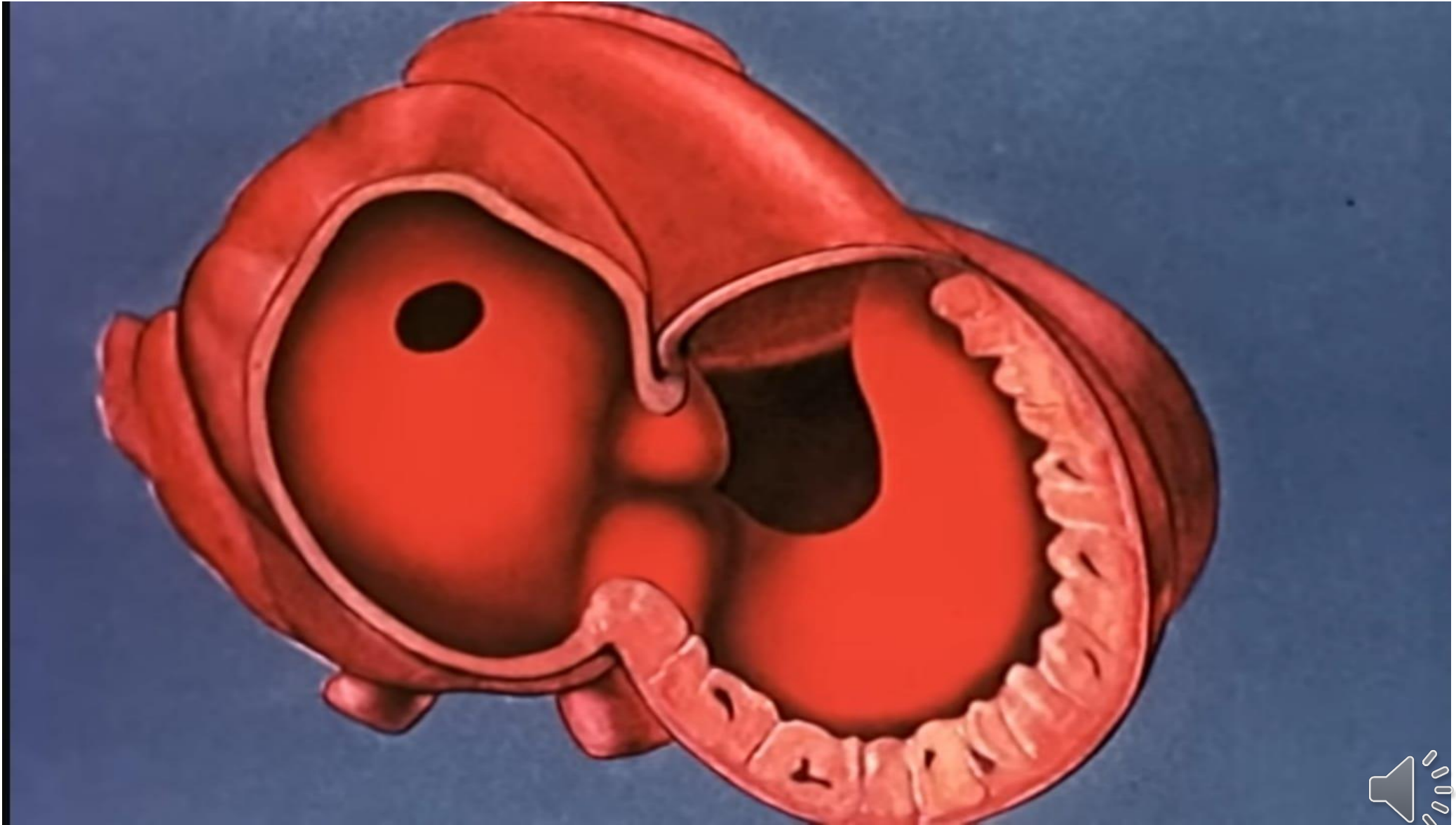
Muscular part : is formed by active ^① cellular proliferation and by dilatation and ^② fusion of the ventricular wall

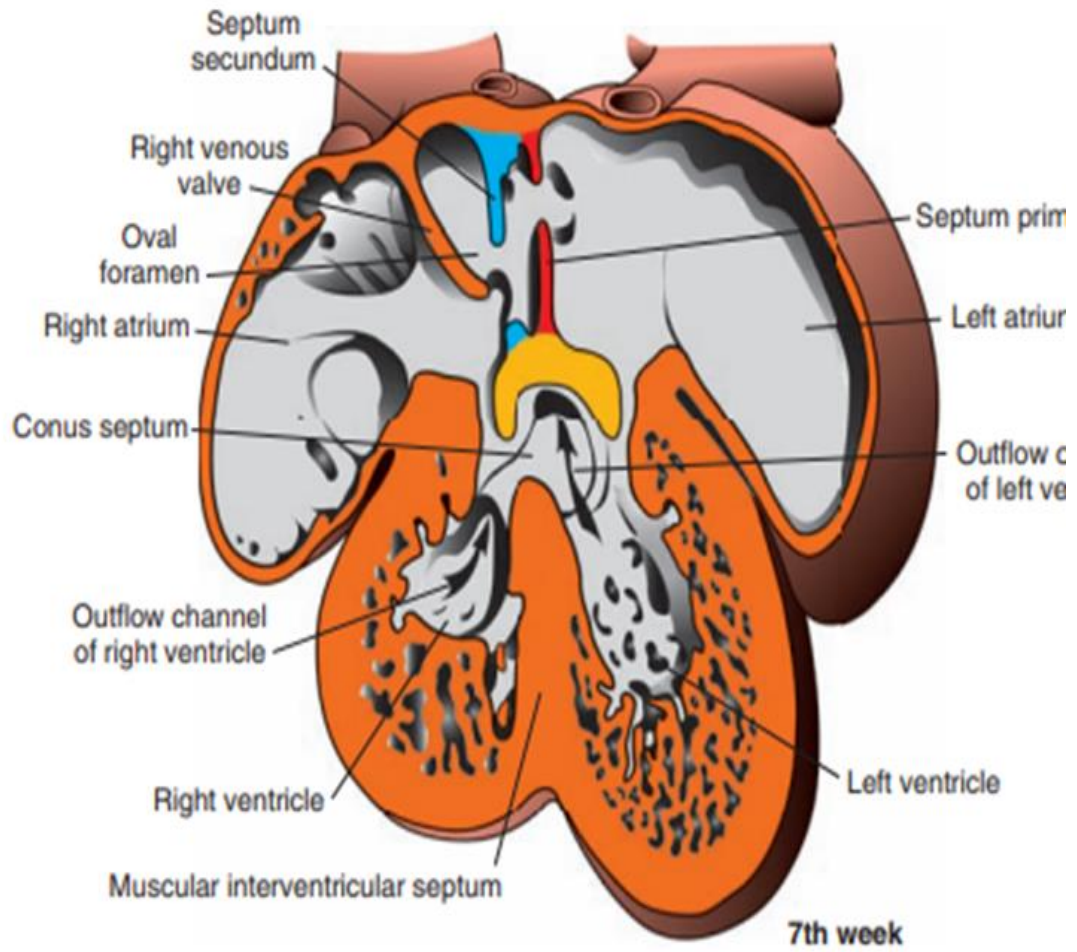
Membranous part : from endocardial cushion and the bulbar septum

← الجرز الأسفل

← الجرز الأعلى



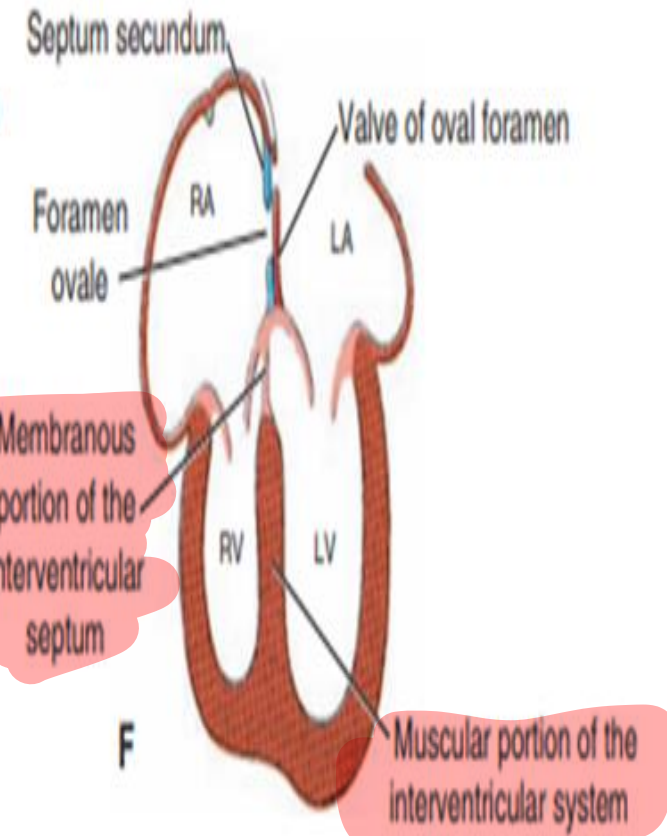




C



D



The interventricular septum (2)

A) Membranous part

- **septum intermedium** (of atrioventricular canal) + **proximal bulbar septum** (of bulbus cordis) (see before).

قناة
proximal part
of bulbus
cordis

infundibulum
(قناة)
vestibule
(قناة البطين)

Active proliferation

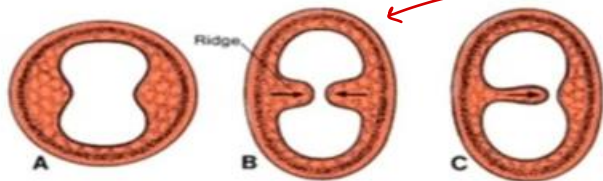
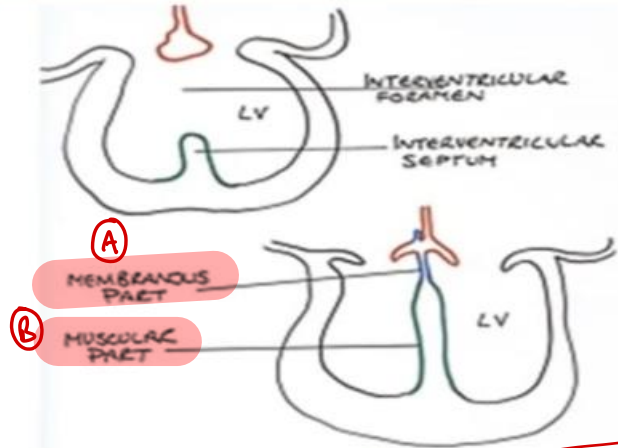
2 mechanisms

Dilatation + fusion of
opposing sides
(walls)

Remember the bulbo-ventricular canal: it is divided by interventricular septum.

B) Muscular part

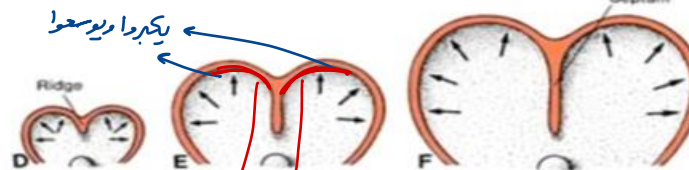
- formed by 2 mechanisms: active cellular proliferation, and dilatation of both ventricles with fusion of the opposing walls.



thickening
الجدارين وتلتقي مع بعضهما

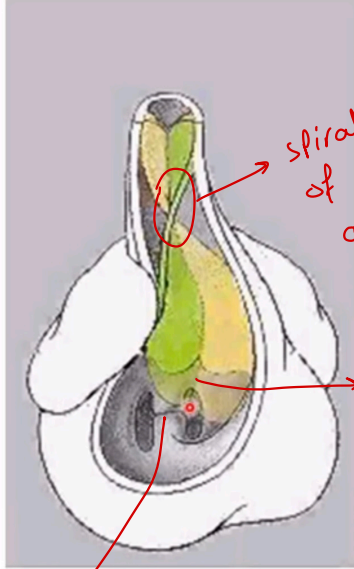
thickening
أو بغير
جهة واحدة وتلتقي مع بقية
septum

Summarize the sources of development of both ventricles?



الخطابين
(fusion)



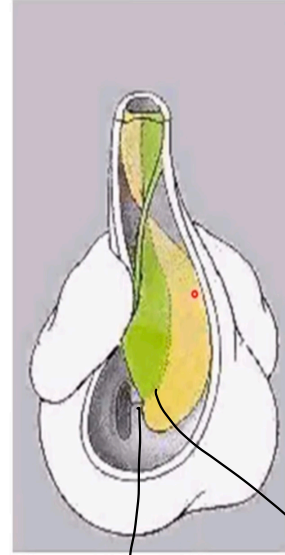


spiral septum
of Truncus
arteriosus

septum
Bulbus cordis

two smooth
outflowing
parts

septum intermedium



septum intermedium, bulbar septum
membranous part of inter ventricular
septum

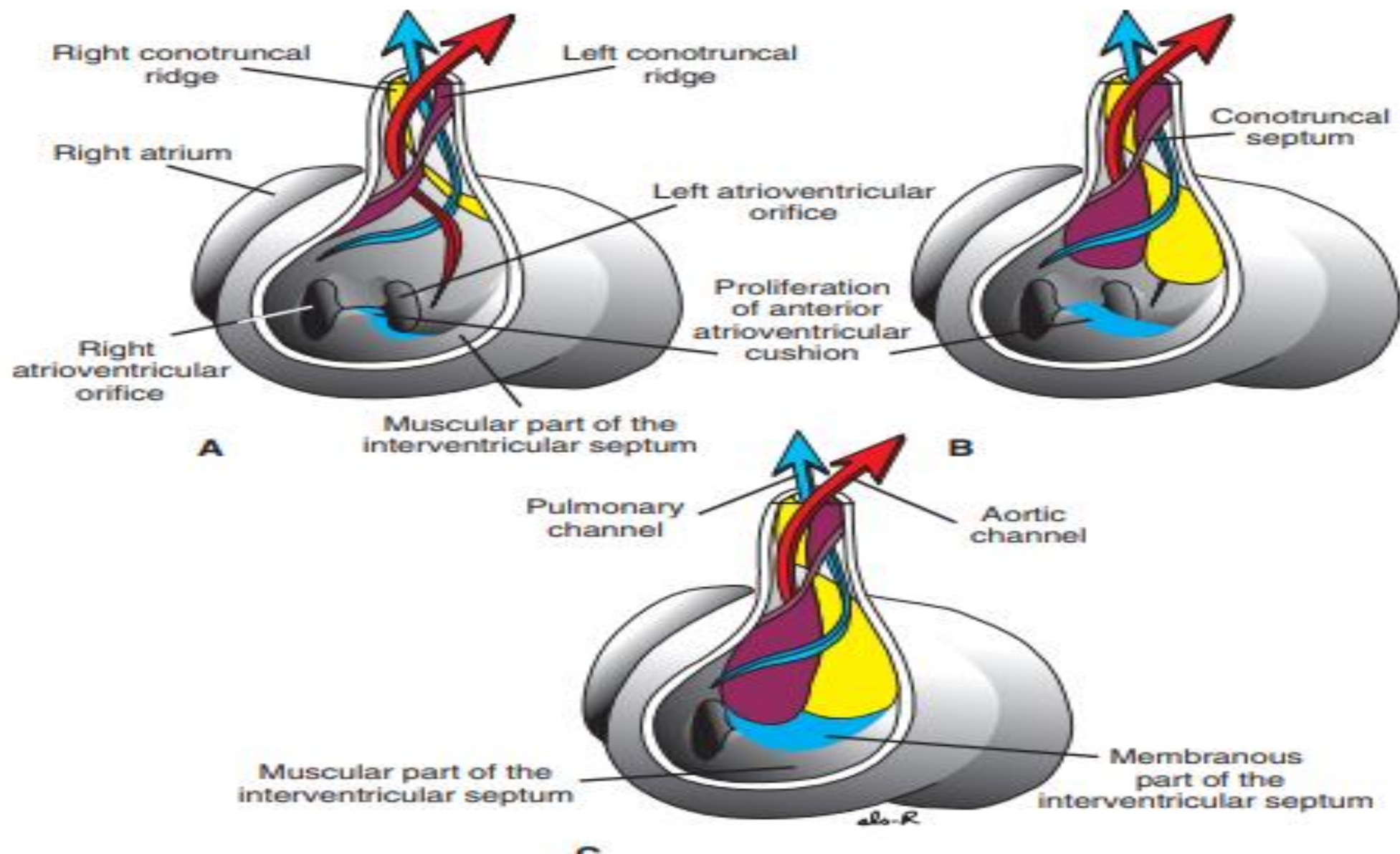
SEPTUM FORMATION IN THE TRUNCUS ARTERIOSUS AND CONUS CORDIS

- During the fifth week, pairs of opposing ridges appear in the truncus.
- These ridges, the truncus swellings, or cushions, lie on the right superior wall (right superior truncus swelling) and on the left inferior wall (left inferior truncus swelling)

← 2 ridges رج يفوق اتجاه بعضهم حتى يلتحموا ويعدوها صير لهم rotation (بجعلوا زي الزمير) They are continuous with bulbar septum

- The right superior truncus swelling grows distally and to the left, and the left inferior truncus swelling grows distally and to the right.





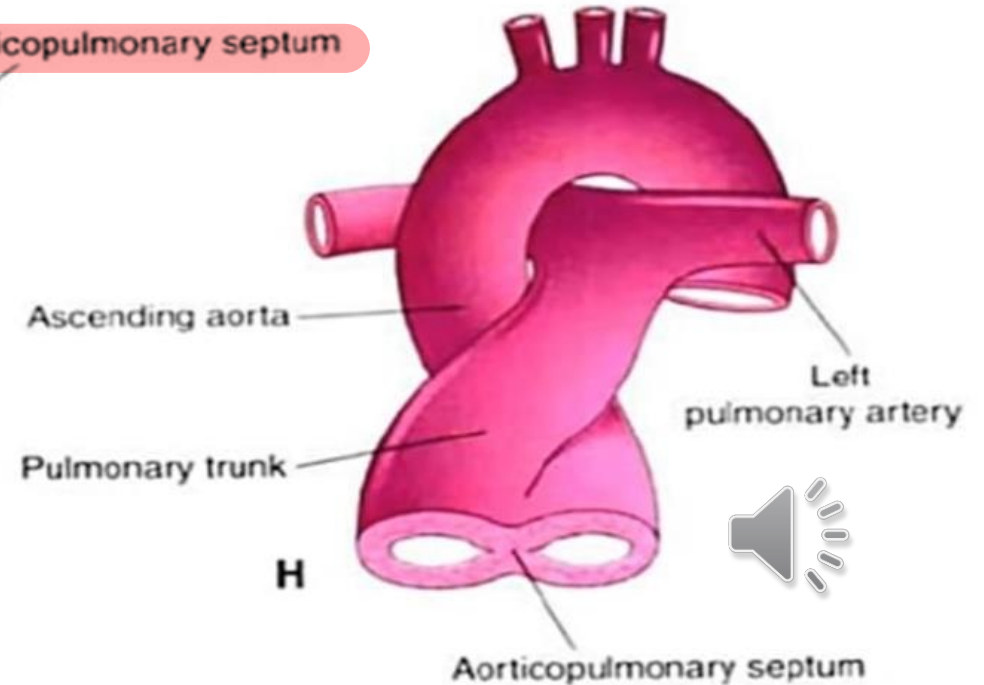
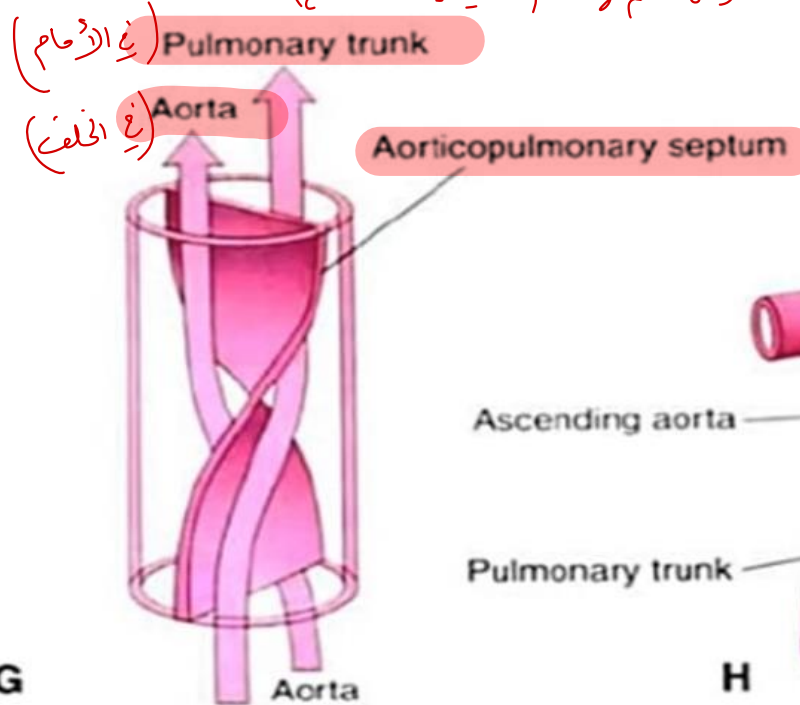
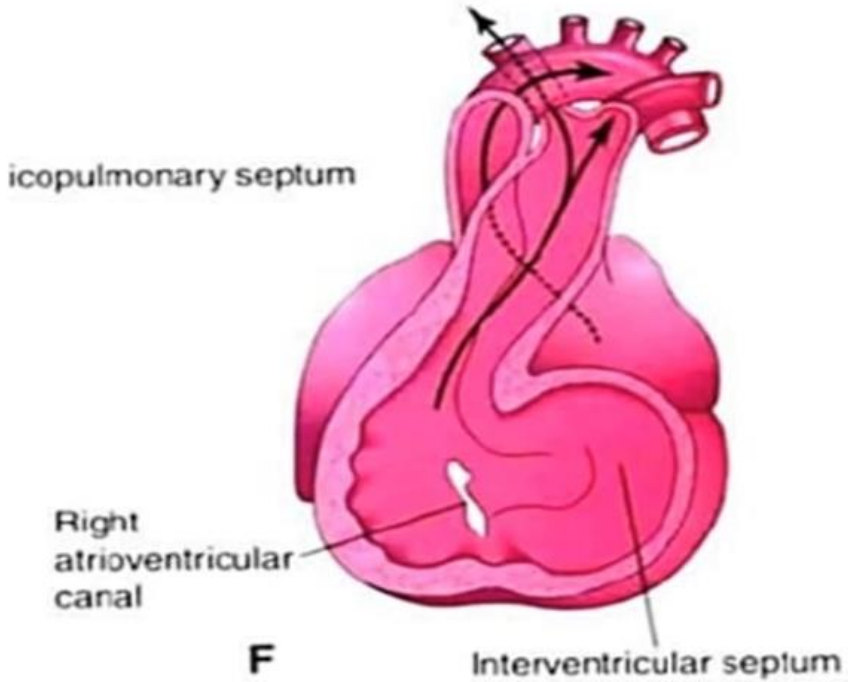
Truncus arteriosus
 anterior تكو Pulmonary Trunk
 aorta وبعده تصبع Posterior لها .

Truncus arteriosus

- Its upper part dilates forming **aortic sac**.
- Its lower part is divided by (**spiral septum**) into **ascending aorta** and **pulmonary trunk**.
- All septa develop in **4th week** except **aortico-pulmonary septum** which develops in **5th week**.

وينتج عن هذا ← aorta + pulmonary Trunk
 1 ح تلفظ صوالية بعد وجرم
 cusps - Valves تنكب
 بالتالي ينتج
 aorta 1 anterior 2 posterior
 pulmonary 2 anterior 1 posterior

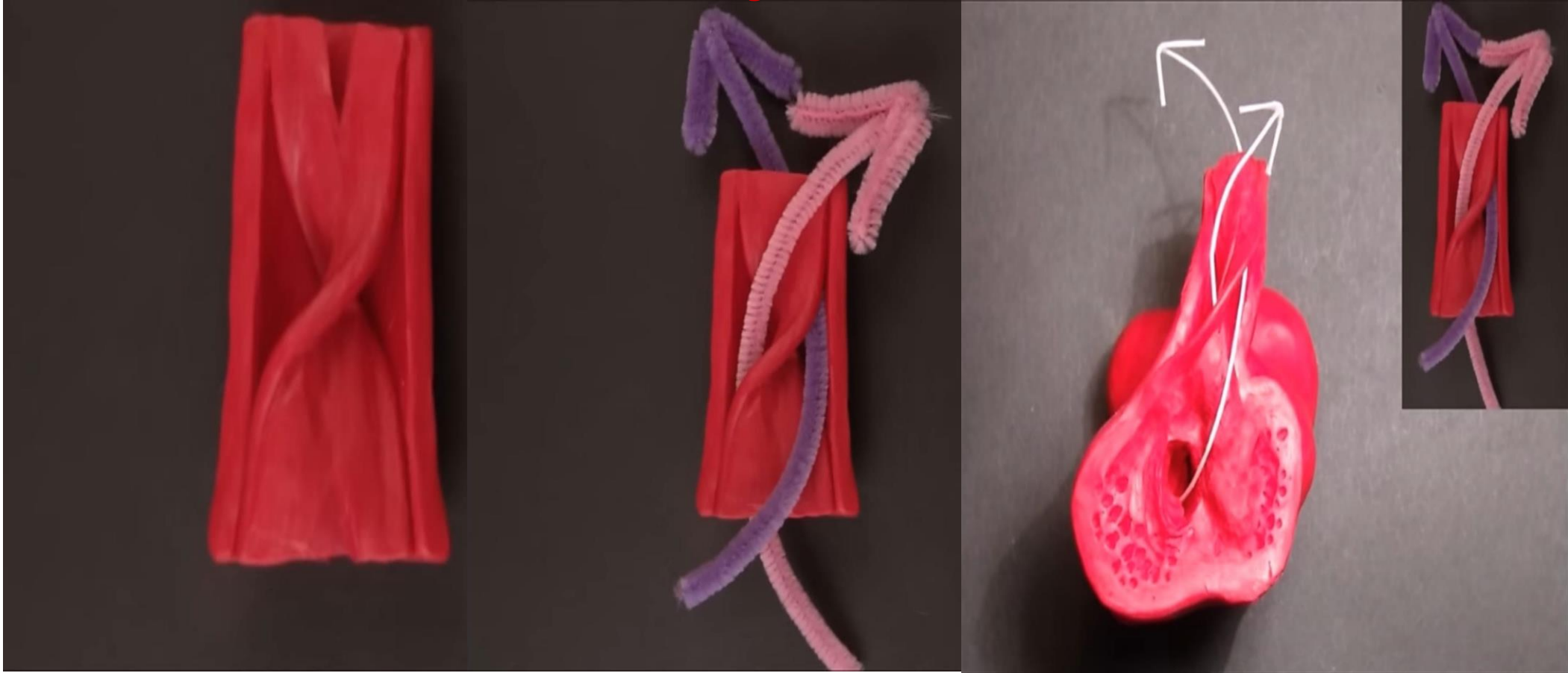
لأنه لازم 2 ventricle يكونوا تقمدا
 outflowing part + vestibule فيه infundibulum
 Bulbar septum + تكونت (من تلفظ مع الدم عيشي بالاسم الصحيح)



Semilunar valve (aorta)
Aorta

Bulbar septum & spiral septum
←

Semilunar valve (pulmonary)
Pulmonary Trunk



orifice of pulmonary $\xrightarrow{\text{no NSS}}$ Bulbus cordis

continuous with



pulmonary trunk $\xrightarrow{\text{no NSS}}$ Truncus arteriosus

orifice of aorta $\xrightarrow{\text{no NSS}}$ Bulbus cordis

continuous with



Ascending Aorta $\xrightarrow{\text{no NSS}}$ Truncus arteriosus.

بعد ما كمل له الانجاب .
هذا Septum

- Hence, while growing toward the aortic sac, the swellings twist around each other, foreshadowing the spiral course of the future septum.
- After complete fusion, the ridges form the aortopulmonary septum, dividing the truncus into an aortic and a pulmonary channel.
- When the truncus swellings appear, similar swellings (cushions) develop along the right dorsal and left ventral walls of the conus cordis .



- The conus swellings grow toward each other and distally to unite with the truncus septum.
- When the two conus swellings have fused, the septum divides the conus into an anterolateral portion (the outflow tract of the ^{pulmonary Trunk} right ventricle) and a posteromedial portion (the outflow tract of the left ventricle)
^{Aorta}



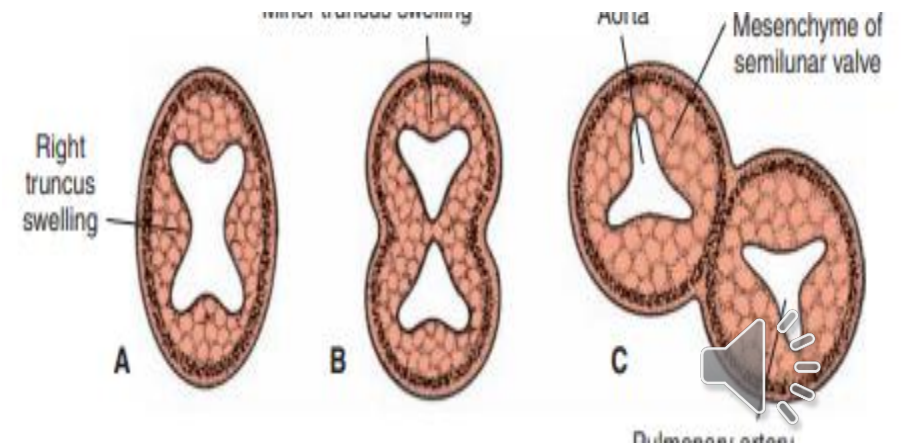
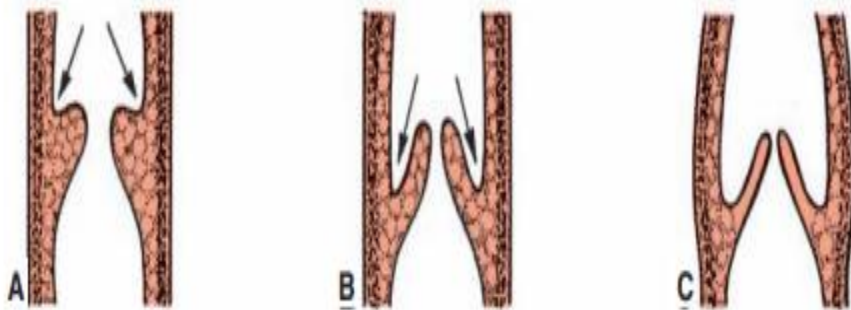
SEMILUNAR VALVES

Value المطبوعة في قفصة
Pulmonary → aorta
Artery

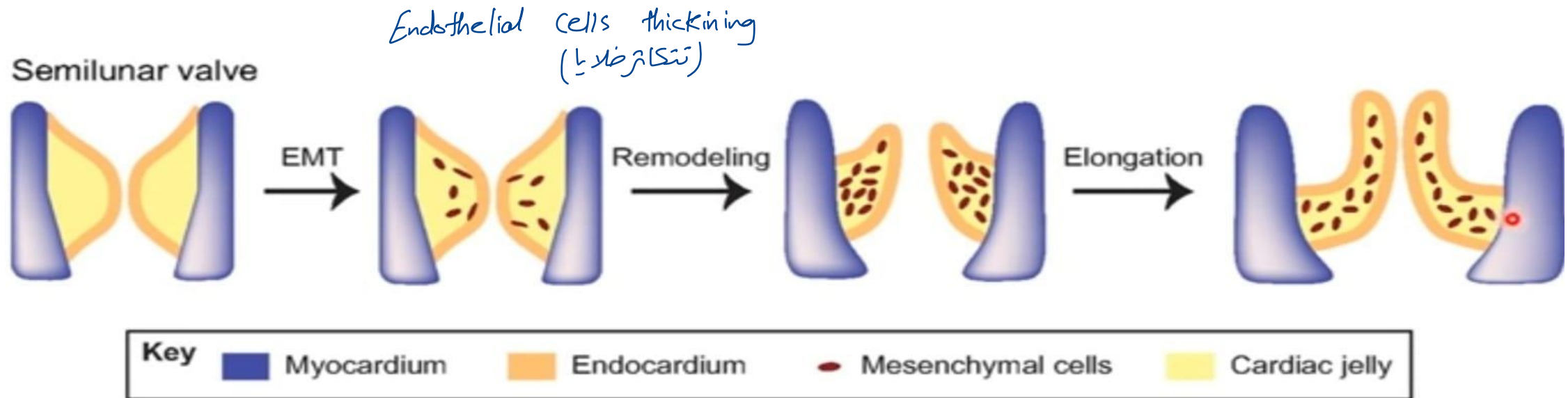
- 3 epithelial thickenings (tubercles) form at both the aortic and pulmonary orifices
- Gradually, the tubercles hollow out at their upper surface, forming the semilunar valves .
صار لهم تجويف .
- After rotation of those vessels:

Aortic valve will have 1 anterior cusp and 2 posterior

The pulmonary valve will have 1 posterior and 2 anterior



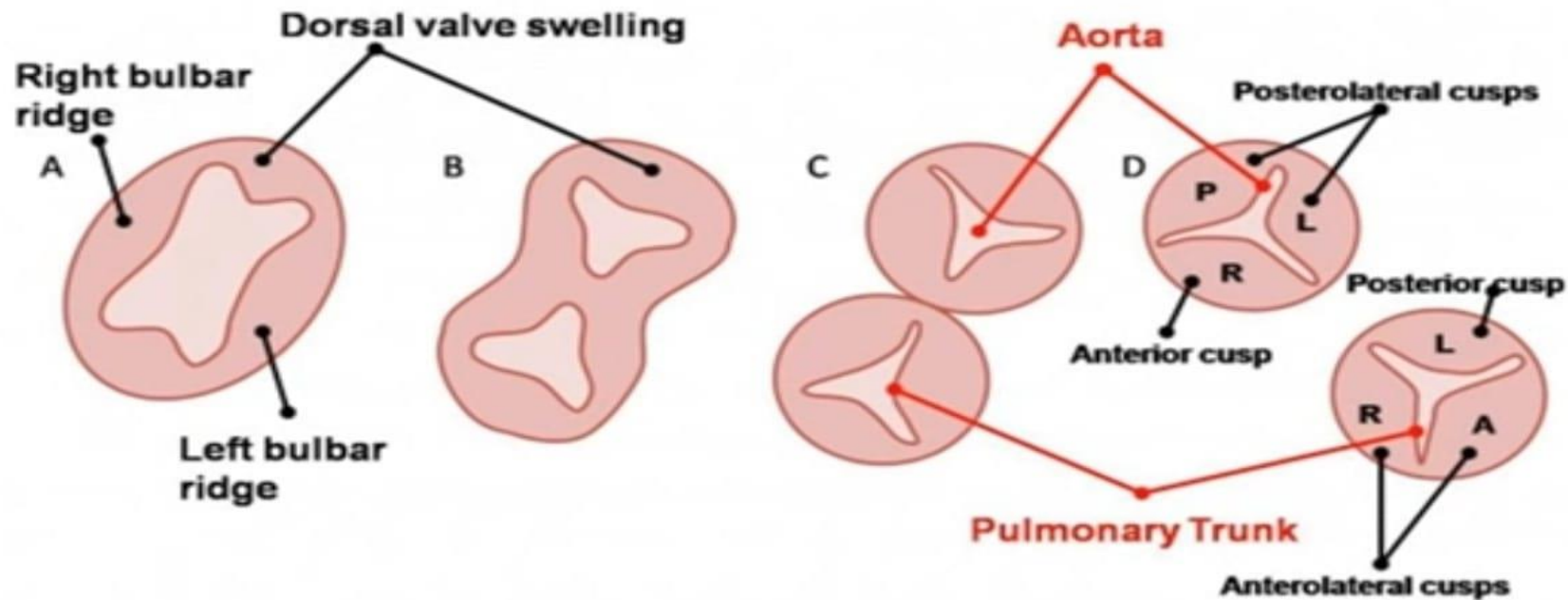
- Aortic and pulmonary orifices show 3 valve swellings for each orifice.
- Each valve swelling becomes hollowed superiorly to form a semilunar cusp.



لأنه يتكون من spiral septum وخلي pulmonary Trunk و aorta وبعد هذا rotation، مع تبدل الأضلاع + valves

تجتمعت راجت
arteries
(التي
artery
بالتي
artery
رافت أكبر
orifice
رافت
مناه)

- Before rotation of aorta and pulmonary trunk: **Aortic valve** has (2 anterior + 1 posterior cusps), while **pulmonary valve** has (2 posterior + 1 anterior cusps).
- After rotation of aorta and pulmonary trunk: **Aortic valve** has (1 Anterior + 2 posterior cusps), while **Pulmonary valve** has (1 Posterior + 2 anterior cusps).

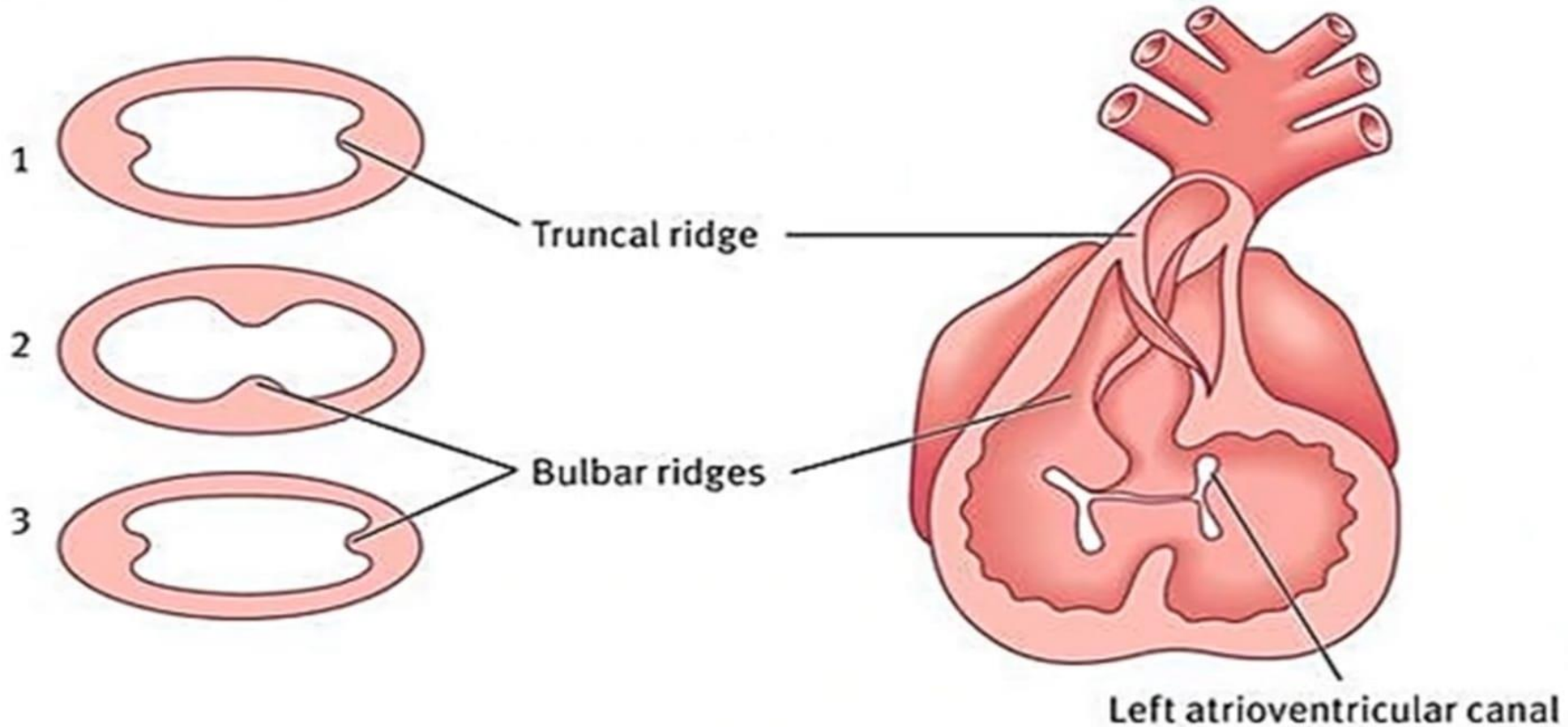


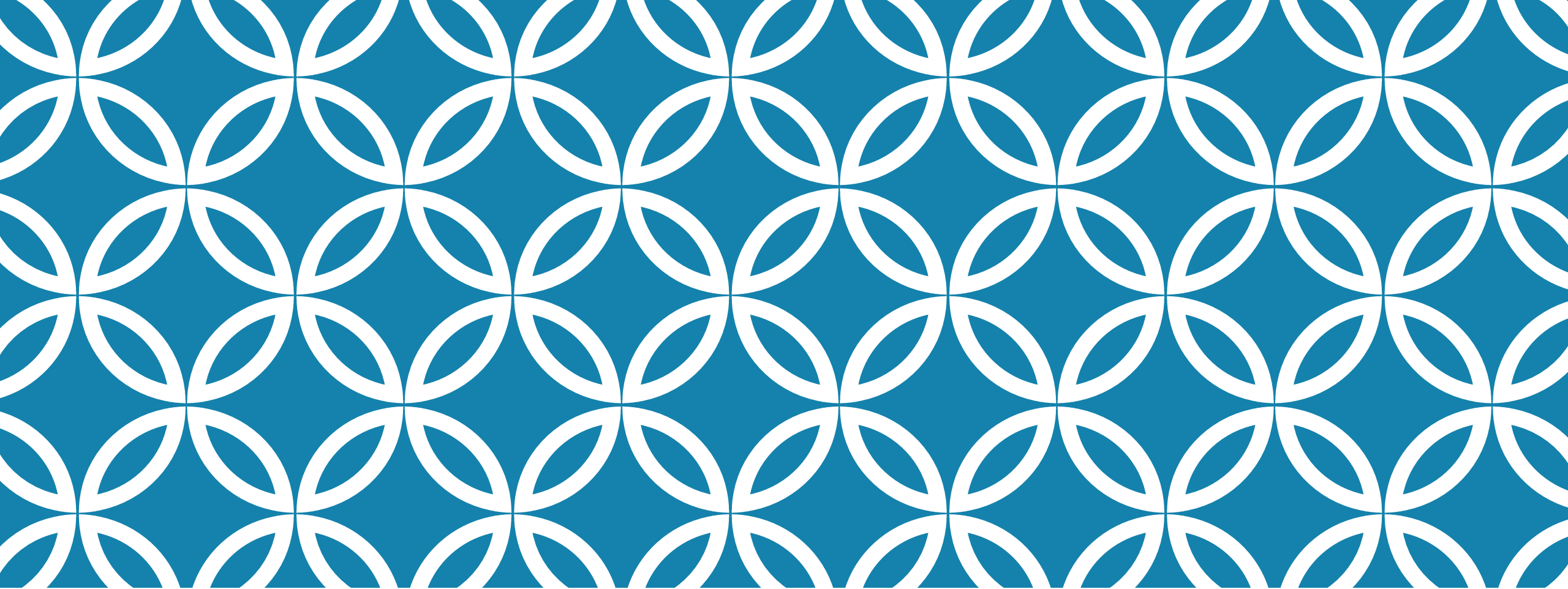
The rough inflowing part of each ventricle → primitive ventricle + the lower part of bulbus cordis

The smooth outflowing part of each ventricle → proximal part of the upper part of bulbus cordis
infundibulum ← قناة
vestibule of left ventricle ← جوف

bulbus cordis ← الجُزء الباطني
قبل ما يبدأ
Truncus arteriosus
orifice of pulmonary ← فتحة
Trunk & aorta .

B Transverse section through an embryo at week 5 C Coronal section through an embryo at week 5





CARDIAC EMBRYOLOGY 5
CONGENITAL ANOMALIES

Dr. Sawsan
S. Shurial

heart بتیز د 3 حالت

① Position

② No defect in septum

③ Transcus arteriosus/outflowing part
of heart مارکونینج سائل/صنید/استع

① Position of the heart

① The apex is directed to the left

→ $\frac{2}{3}$ to the left side of the middle line.
→ $\frac{1}{3}$ to the right

② Inside the thoracic cage

يَمِين DEXTROCARDIA

- The apex of the heart is directed to the right
- This is due to reversal of bending of the heart tube
- If there is no other abnormality, it has no harm and is discovered accidentally
- It could be isolated or a part of situs inversus totalis in which all the organs have reversed positions

↓
يعني كل organs عكس موقعها

(مثلاً / liver على left بدل ما هو على right)



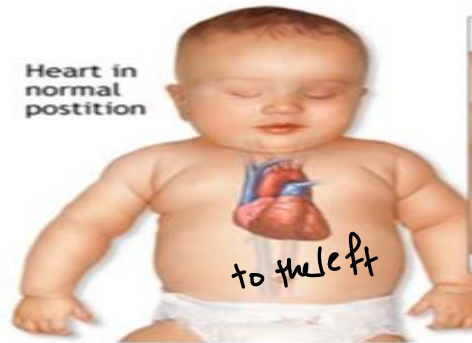
Ectopia Cordis موهنق إقلبته مسكلة

Protrusion of the heart through a gap in the chest wall due to incomplete sternal development. → مالهآ heart مكشوف لبرة

Congenital anomalies of the heart

Abnormal position

- **Dextrocardia:** right sided heart, due to reverse bending of the heart tube.
- **Ectopia cordis:** protrusion of the heart through a gap in the chest wall, due to incomplete sternal development.



ADAM

Ectopic cordis →



SEPTAL DEFECTS

(ASD)

Atrial septal defects:

1. Patent foramen ovale: it is usually benign
2. Endocardial cushion septal defect: situated at the lower part of inter atrial septum
3. Sinus venosus defect: situated at the upper part of the septum (inter atrial septum) → the left venous valve of sinus venosus failed to close the ostium secundum
4. Single atrium : no septum is formed (trilocular heart) with common atrium

تعتبر أيضا
أنواع
Atrial
septal
defects

↓
سبب
septum primum & secundum
ما انفقوا أصلاً

فقط 3 غرف في heart

(mixing between Right & Left atrium)
mixing between oxygenated
& non oxygenated blood

له مضاعفات هامة مثل خلل في الدورة الدموية وارتفاع ضغط الدم ومرض الكبد ومرض الرئة

foramen ovale تنفذ

septum secundum لا يترسب في خط على

septum primum مع أول بيت للطفل

يتكرر هذا valve وبعد فترة يصير إقفال تام

إذا ما تم إقفال ربيعية الفتحة بنسبها

وكنز السبب خفيرة لأنه لا يكون هناك

shunt of blood between
right & left ventricle

+ high pressure of left
atrium → تمنع الدم من الرجوع إليه

لا يجر أنه فيه ASD رج نتوقع أنه في VSD

لأنه endocardial cushion ما تراكمت فقط في

atrial septum كما تراكمت في interventricular septum

سبب

endocardial cushion
septum primum في
جدار في

foramen primum صحت لقفال

سبب

left venous valve
تحت فتحة sinus venosus في
back of the right atrium
ما قفل تماماً مع septum secundum



Ventricular Septal Defects

1. Membranous VSD: the defect in the endocardial cushion or in the proximal bulbar septum.

2. Muscular VSD: due to over cavitation and trabiculations that form an opening. →

صحة يكونه زيادة عنه
الزخم لدرجة أنه
يأكل septum
ويصل منها فتحة .

3. Absence of the septum: this leads to a common ventricle (trilocular heart)

ثلاثة غرف .

← أخطر بكثير من Trilocular heart الناتج من

ASD لأنه الدم في Ventricle كله

امتزج بالتالي مع دمه Non oxygenated blood

وصل إلى organs المهمة

كالدماع .



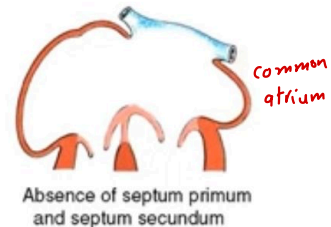
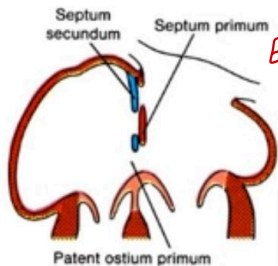
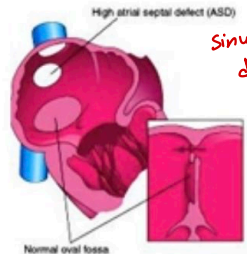
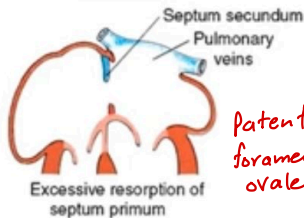
Congenital anomalies of the heart

Abnormal position

Septal defects

Atrial

- **Patent foramen ovale:** a **hole** in the **middle** of the septum (site of foramen ovale).
- **Endocardial cushion ASD:** a **hole** in the **lower** part of the septum.
- **Sinus venosus ASD:** a **hole** in the **upper** part of the septum.
- **Common atrium (tri-locular heart).**



قسط العنق
endocardial cushion

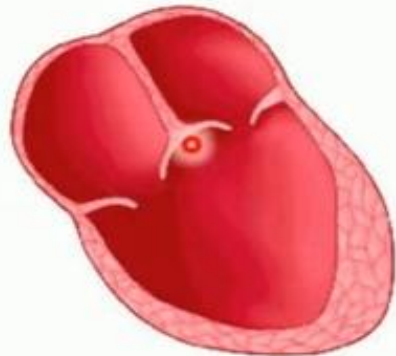
Congenital anomalies of the heart

Abnormal position

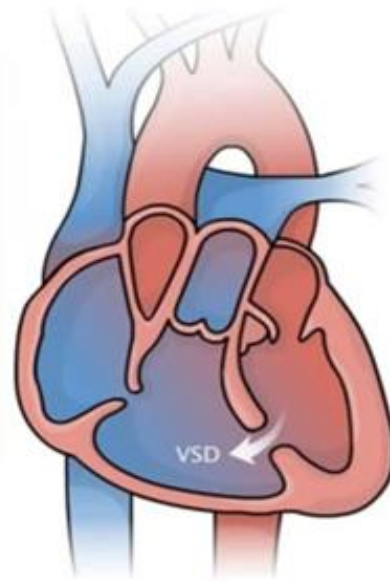
Septal defects

Atrial

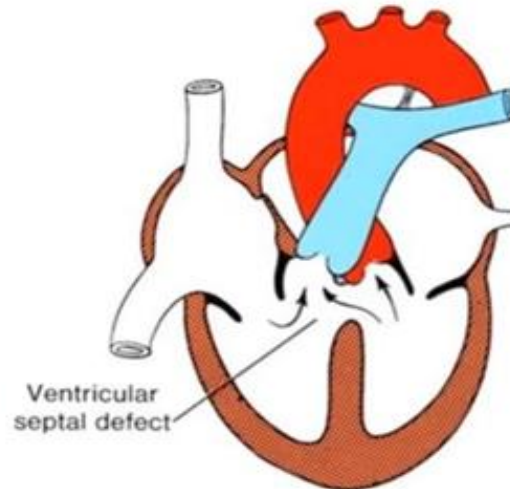
Ventricular



Common ventricle



Muscular
VSD



Membranous
VSD

- **Membranous VSD:** the defect is present in the membranous part.
- **Muscular VSD:** the defect is present in the muscular part.
- **Common ventricle:** (tri-locular heart).



TRUNCUS ARTERIOSUS DEFECTS

Arterial end of heart tube → aortic sac
 spiral septum
 pulmonary Trunk & Aorta

① إمام تتكون أصلًا

② تكونت ولم تكن spiral

③ تكونت جائت spiral

ولكن لم تكن في المنتصف
 ما عالتت بعد منبع
 bulbar septum

Truncus
 one Trunk
 oxygenated & Non oxygenated blood
 mix together
 بالتالي نسبة O_2 في الدم
 قليلة فخرج بصير معاه
 Cyanosis (ازرقان)

لذلك Truncus arteriosus defects يعتبره
 one of the cyanotic heart disease.

1. Failure of formation of the spiral septum:

Leads to persistent truncus arteriosus
 مع تضيق زري ماهي

2. The septum is not spiral:

Aorta will rise from right ventricle and the pulmonary artery will rise from the left ventricle (transposition of great arteries) (TGA)
 كل الجسم يوصلها deoxygenated blood → aorta عند طرفه

3. The spiral septum is deviated: leads to stenosis of either orifices like pulmonary

stenosis → orifice المقابل الثاني واسع
 (Not equal division)



4

Fallot tetralogy:

أيضاً يُعتبره
cyanotic heart disease

because of the mixing
of oxygenated & Non oxygenated blood → بالتالي O_2 في الدم قليل .

This is a group of abnormalities that present together

1. Pulmonary stenosis: due to unequal truncus arteriosus division

Septum دخل زيادة

على Pulmonary area
ف عمل Pulmonary stenosis

Against high pressure الدم رفع
أضاح

تضخم نسيجة
الجدار الكبير
المستوي

2. Right ventricular hypertrophy

3. Overriding of aorta

لأنه اتسع فصار يأخذ
both left & Right
Ventricles

4. Membranous VSD: due to bulbar septal fusion defect

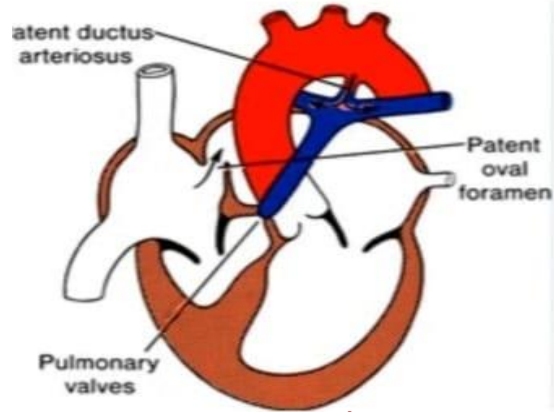
لأنه حصل خلل في

fusion between
spiral septum & bulbar
septum



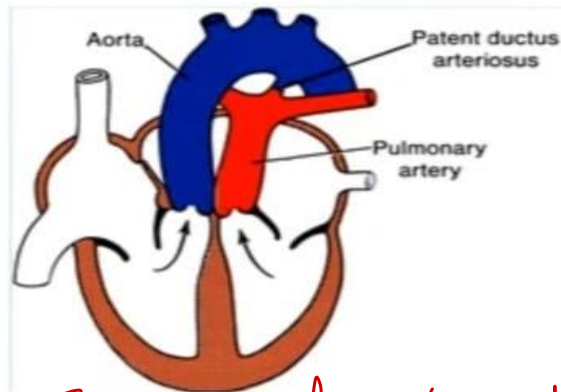
Congenital anomalies of the heart

Abnormal position

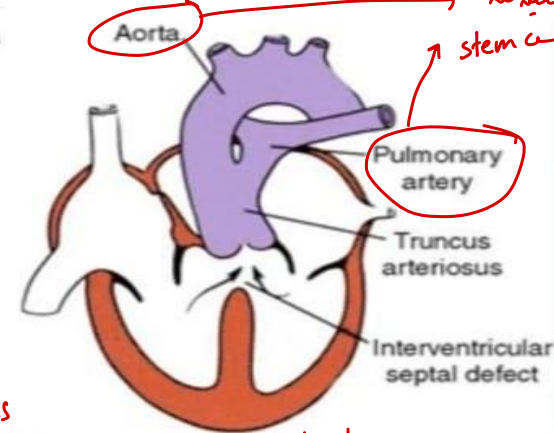


stenosis of an orifice

Septal defects



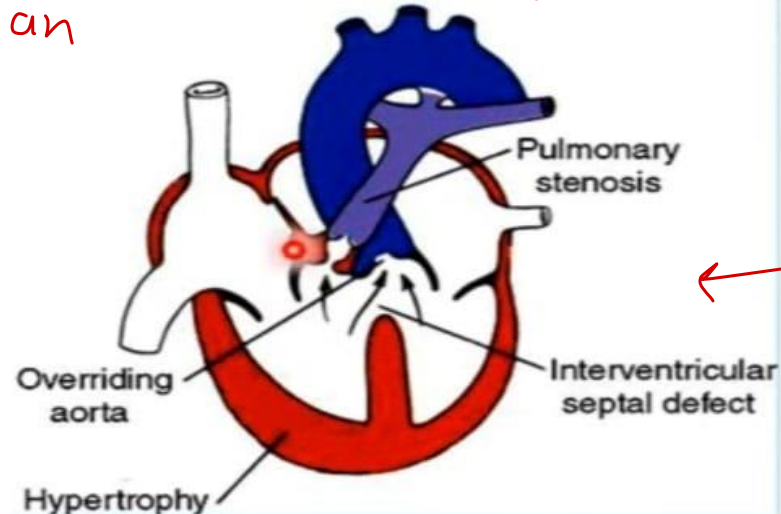
Transposition of great vessels



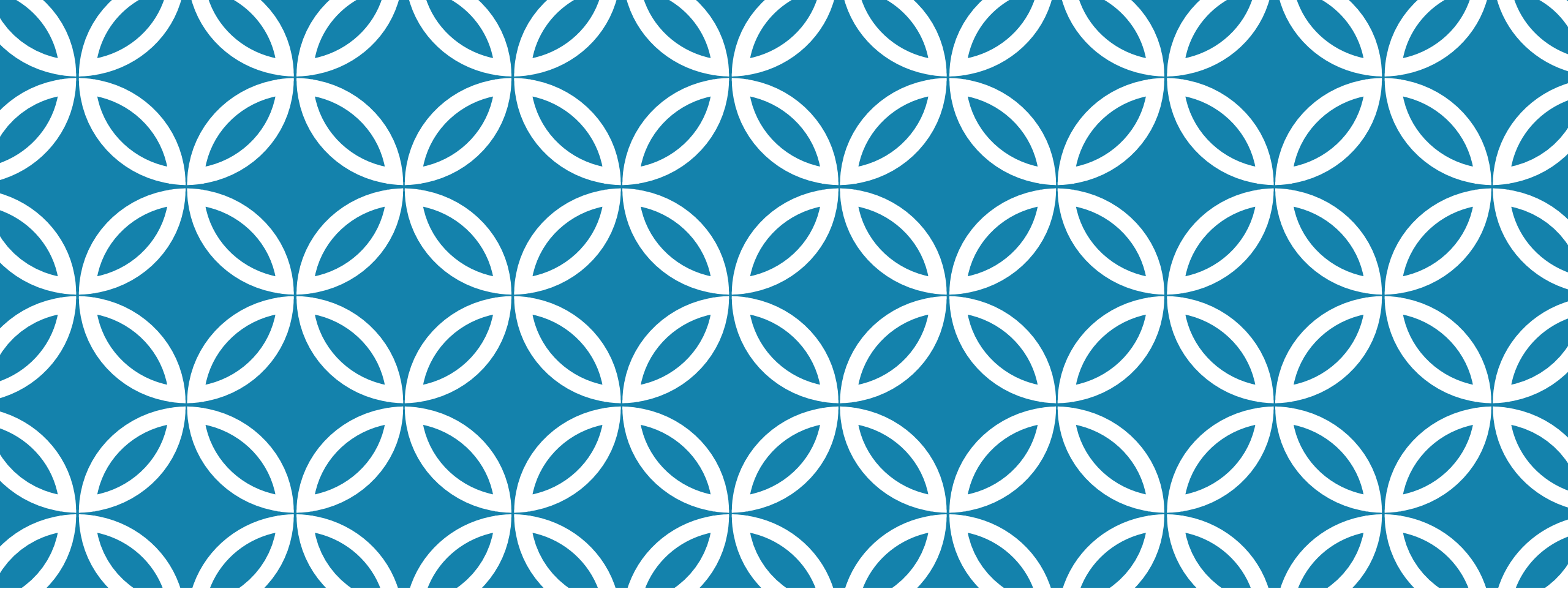
persistent truncus arteriosus

Truncus arteriosus problems

- **Persistent truncus arteriosus:** no aortico-pulmonary septum.
- **Transposition of great vessels:** there is septum but not spiral.
- **Stenosis of an orifice:** there is spiral septum, but the division is unequal.



Fallot's tetralogy: pulmonary stenosis + right ventricular hypertrophy + over-riding aorta (wide aortic orifice) + membranous VSD



CARDIAC EMBRYOLOGY 6 ARTERIES

*Dr. Sawsan
S. Shw*

VESSELS IN THE EMBRYO ARE:

1. Ventral Aortic Sac:

- It is the dilated cranial part of truncus arteriosus
- It has 2 horns

2. RT and LT dorsal aortae: *organs & body wall* (Main arteries)

Each dorsal aorta gives:

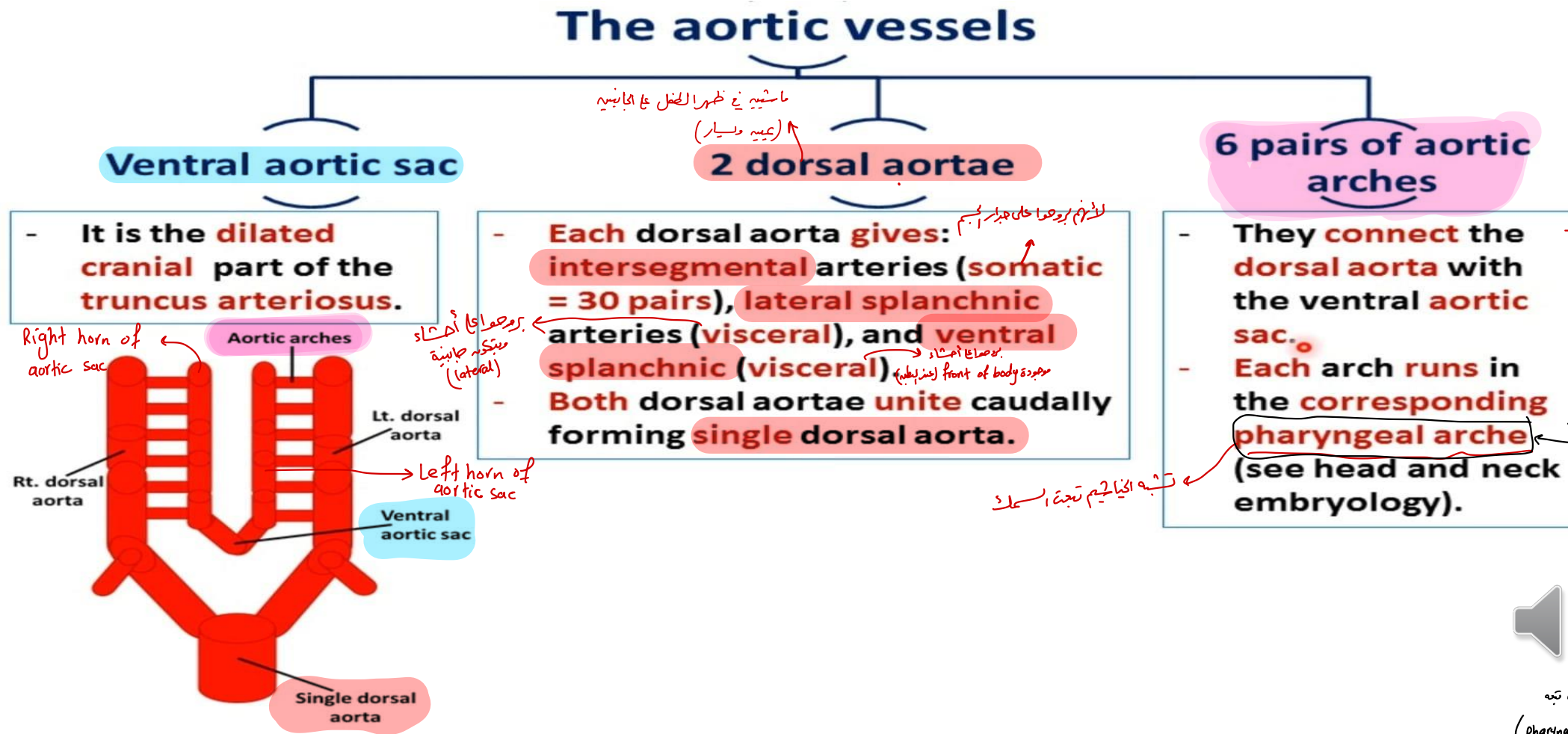
- lateral splanchnic (visceral) arteries that supplies lateral organs
- 30 somatic intersegmental arteries that supply the body wall
- ventral splanchnic (visceral) arteries that supplies ventral organs

RT and LT dorsal aortae unite caudally to form the single dorsal aorta



3. 6 pairs of aortic arches

- These arches connect dorsal aortae to the horns of the ventral aortic sac
- Each arch runs in the corresponding pharyngeal arches that will form the face



Left 6 of aortic arches
↓
Left horn of aortic sac
Left dorsal aorta

Right 6 of aortic arches
↓
Right horn of aortic sac
Right dorsal aorta

الرجل قبل ما يتكون كان عبارة عن 6 على الجسم و 6 على إمتداد
وكل arch منهم له
mesoderm & ectoderm & endoderm
nerve & blood vessels
خاصة منه عظام

بعضها على إمتداد العظام والعظام
المتعلقة للرجل

عظام صلبة عن 6 aortic arches

كل pharyngeal arch ما بينه artery

(aortic arteries) بينوا في pharyngeal arches

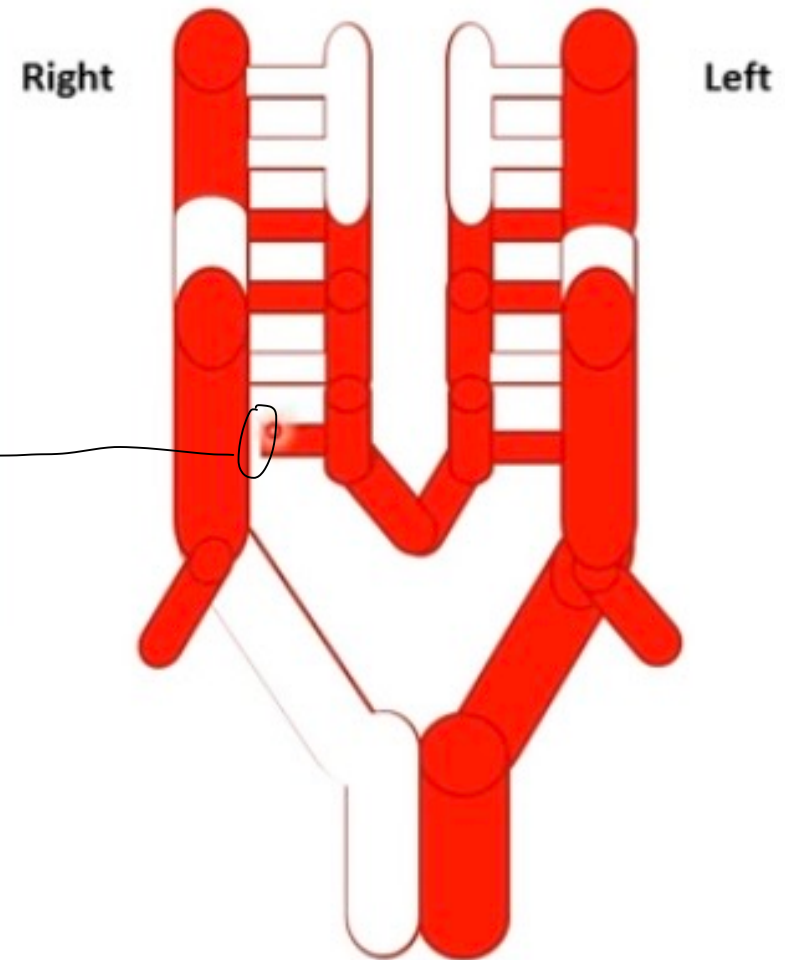
The following arteries disappear:

1. First, second and fifth arches except remnants of first and second arches
2. Distal part of Rt sixth aortic arch, but that on the left does not disappear
3. The parts of the dorsal aortae that connect third and fourth arches
4. The vessel connecting RT seventh intersegmental artery and right dorsal aorta



The following disappears:

- **1st, 2nd** (almost completely), and **5th** pairs of aortic arches (on **both** sides).
- **Distal part of right 6th** aortic arch.
- **Parts of dorsal aortae: connection between 3rd and 4th arches (on both sides) + connection between 7th intersegmental and dorsal aorta on right side.**



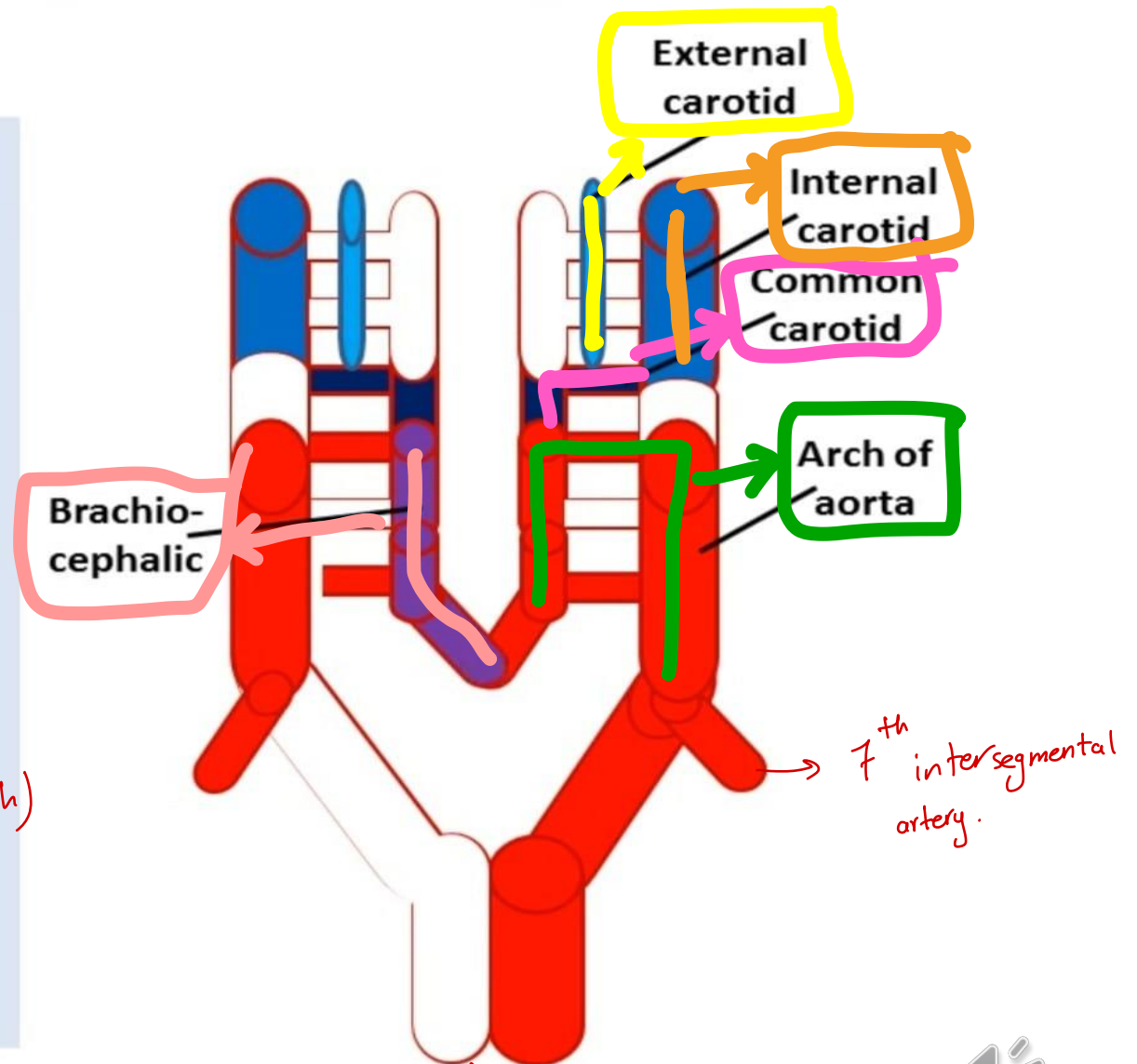
So the fate will be:

- Arch of aorta = left horn of aortic sac + left 4th arch + left dorsal aorta between 4th arch and 7th intersegmental artery.

- Carotid system: **common** carotid = proximal part of 3rd aortic arch. **Internal** carotid = distal part of dorsal aorta. **External** carotid = bud from common carotid. (From 3rd aortic arch)

- Brachiocephalic artery = right horn of aortic sac.

right (3rd) common carotid
& right subclavian (4th)

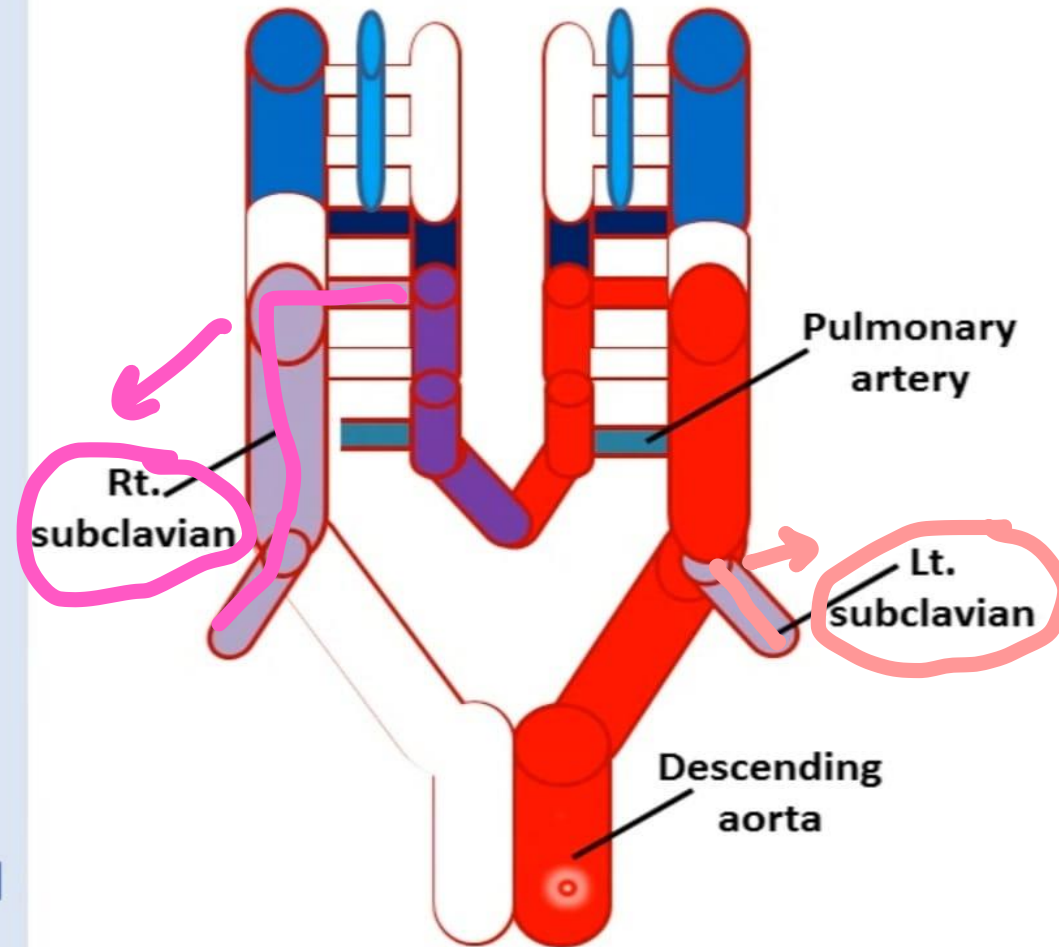


left common carotid artery → Arch of aorta ~ 2/3
right common carotid artery → Brachiocephalic ~ 2/3 (from right horn of aortic sac)



So the fate will be:

- Subclavian arteries: Aorta a?
- **Right** = right 4th arch + part of right dorsal aorta + right 7th intersegmental artery.
- **Left** = left 7th intersegmental artery.
- Pulmonary arteries = 6th aortic arches. The left is connected to the arch of the aorta by ductus arteriosus. → connection between left pulmonary artery & arch of aorta
- Descending aorta = left dorsal aorta distal to 7th intersegmental artery.



SO THE FATE WILL BE

ARCH OF AORTA:

- It is formed of 3 parts:
 - LT horn of aortic sac
 - LT fourth aortic arch
 - Dorsal aorta from the fourth arch to the seventh intersegmental artery
- Arch of aorta continues as the descending aorta



THE CAROTID SYSTEM

- LT common carotid is formed from third aortic arch
 - LT internal carotid is formed from the dorsal aorta
 - LT external carotid arises as a sprout from common carotid
-
- RT common carotid is formed from third aortic arch
 - RT internal carotid is formed from the distal aorta
 - RT external carotid arises as a sprout from RT common carotid



Note:

The right horn of aortic sac is the brachiocephalic artery

So, LT common carotid arises from arch of aorta directly but the RT common carotid arises from brachiocephalic artery

SUBCLAVIAN ARTERIES:

Rt subclavian artery is formed of Rt fourth arch , part of dorsl aorta and Rt seventh intersegmental artery

LT subclavian artery is the left seventh intercostal artery



PULMONARY ARTERIES:

They are formed from the sixth aortic arches

Note:

The left sixth arch remains connected to arch of aorta (ductus arteriosus) , but the right one loses the connection

DESCENDING AORTA

Forms by union of the left dorsal aorta near the seventh intersegmental artery with the single dorsal aorta



Notes:

1. remnants of first aortic arch give maxillary artery
2. remnants of second aortic arch gives hyoid artery
3. RT recurrent laryngeal nerve hooks below right subclavian artery, but left recurrent laryngeal nerve hooks below ductus arteriosus

the arch of aorta



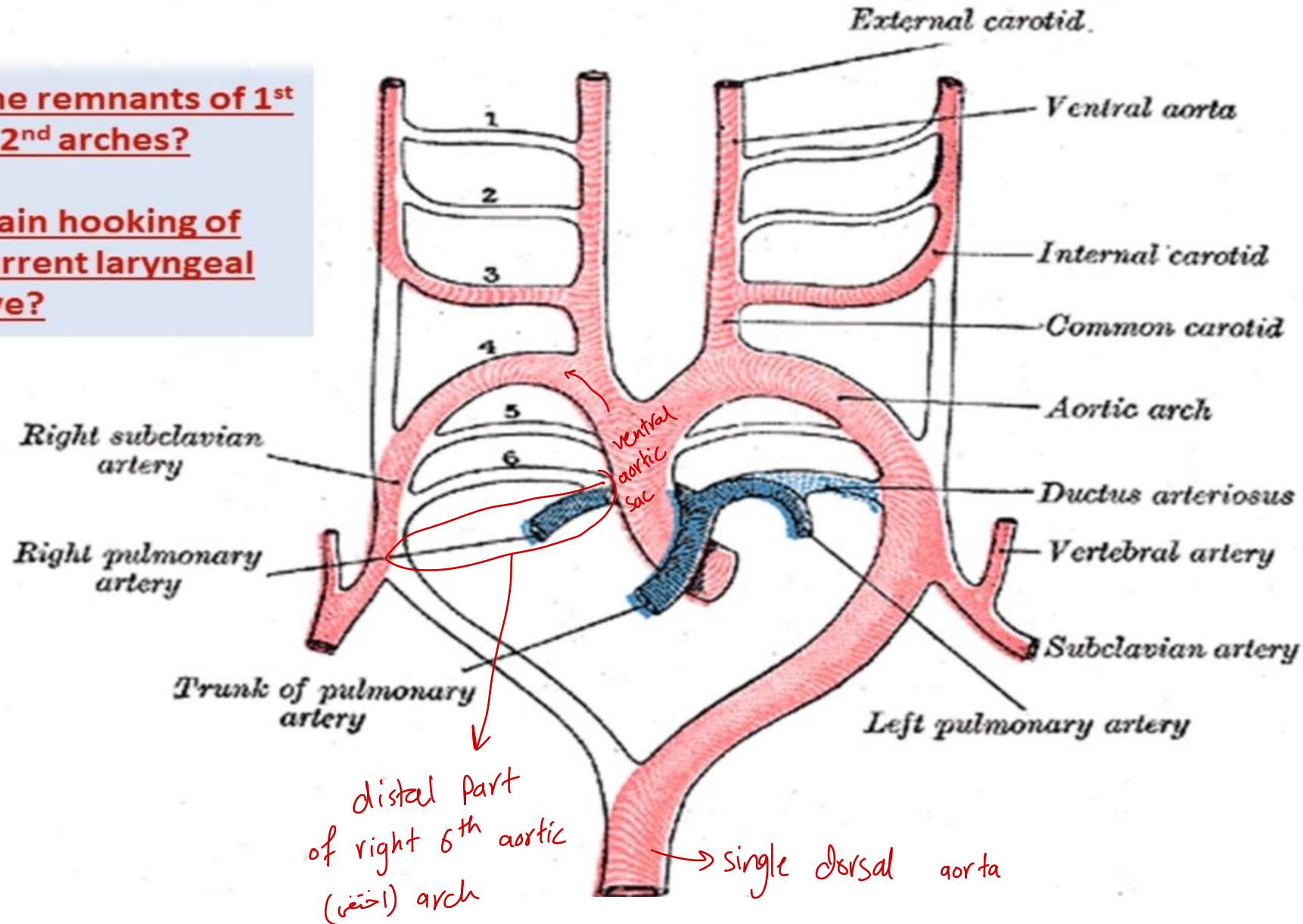
وَرَقَ لِيَكْفَهُ عَجَبًا

ligamentum arteriosum



Name remnants of 1st and 2nd arches?

Explain hooking of recurrent laryngeal nerve?



THE INTERSEGMENTAL ARTERIES (30)

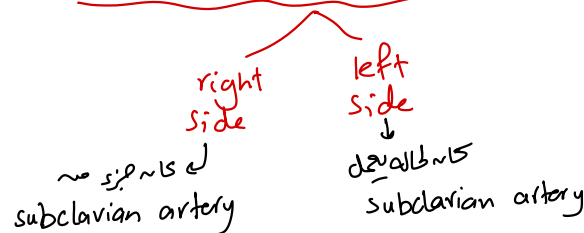
AT CERVICAL REGION

The first six arteries form longitudinal anastomosis to form these arteries:

- Ascending cervical artery: from precostal anastomosis in front of transverse processes of cervical vertebrae.
- Deep cervical artery: from anastomosis behind transverse processes.
- Vertebral artery: it passes through the foramina of transverse processes ^{↖ anastomosis}
- Internal thoracic artery

cervical region ~ 

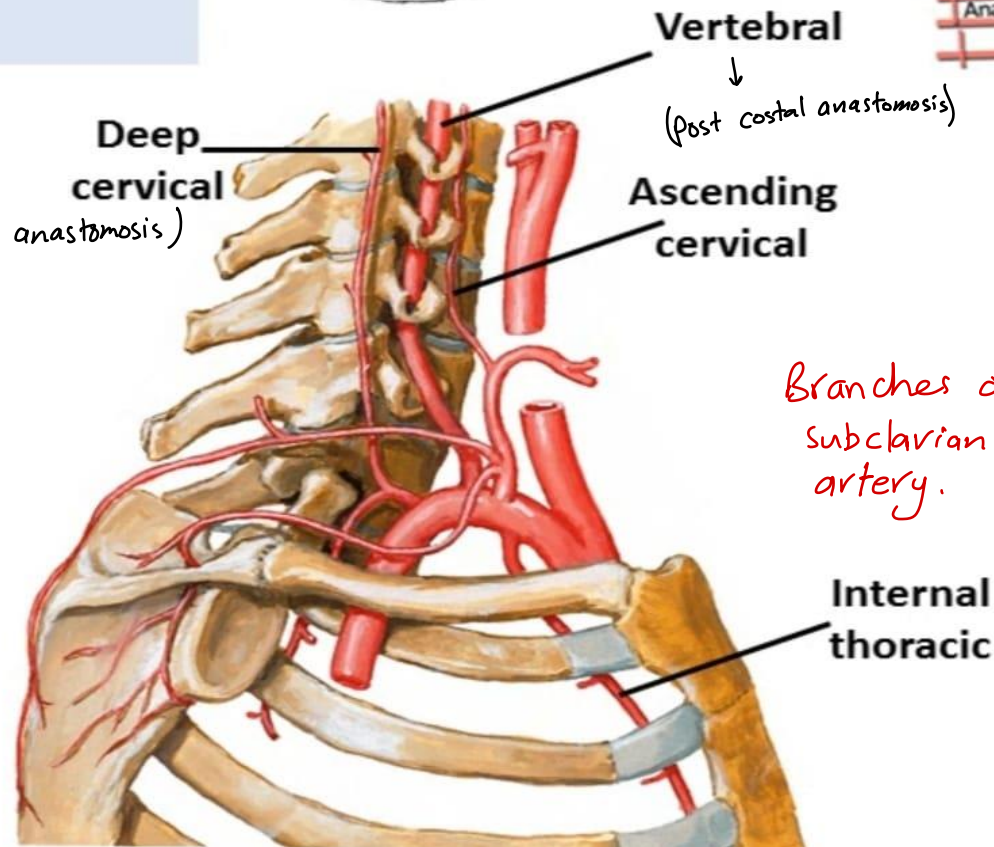
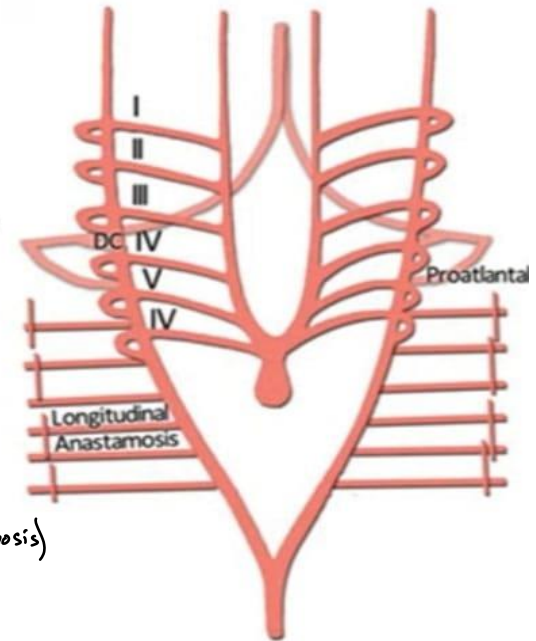
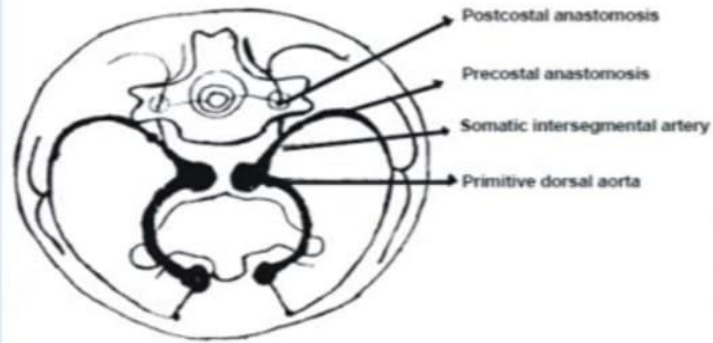
Remember that the seventh segmental artery forms subclavian artery



Dorsal aorta $\xrightarrow{\text{طولي}}$ intersegmental arteries

30 pairs of intersegmental arteries:

- 1-6 cervical: longitudinal anastomosis (explain?). طولي
- 7th cervical: subclavian artery.



(Transverse process $\rightarrow$ anastomosis)

Left subclavian $\rightarrow$ Arch of aorta طالع

Right subclavian $\rightarrow$ Right aortic sac طالع
 Right 4th arch $\rightarrow$
 7th intersegmental artery $\rightarrow$



AT THORACIC REGION:

They form intercostal arteries

AT LUMBAR REGION:

They form 5 lateral lumbar arteries

The fifth one is the common iliac artery

AT SACRAL REGION:

They form lateral sacral arteries

Note:

The last part of the dorsal aorta becomes narrow and is called median sacral artery

30 pairs of intersegmental arteries (cont.):

- Thoracic: intercostal and subcostal. (thoracic جبهه)

- 1-4 lumbar: lumbar arteries (lateral)

- 5th lumbar: common iliac artery (descending aorta - ساق)

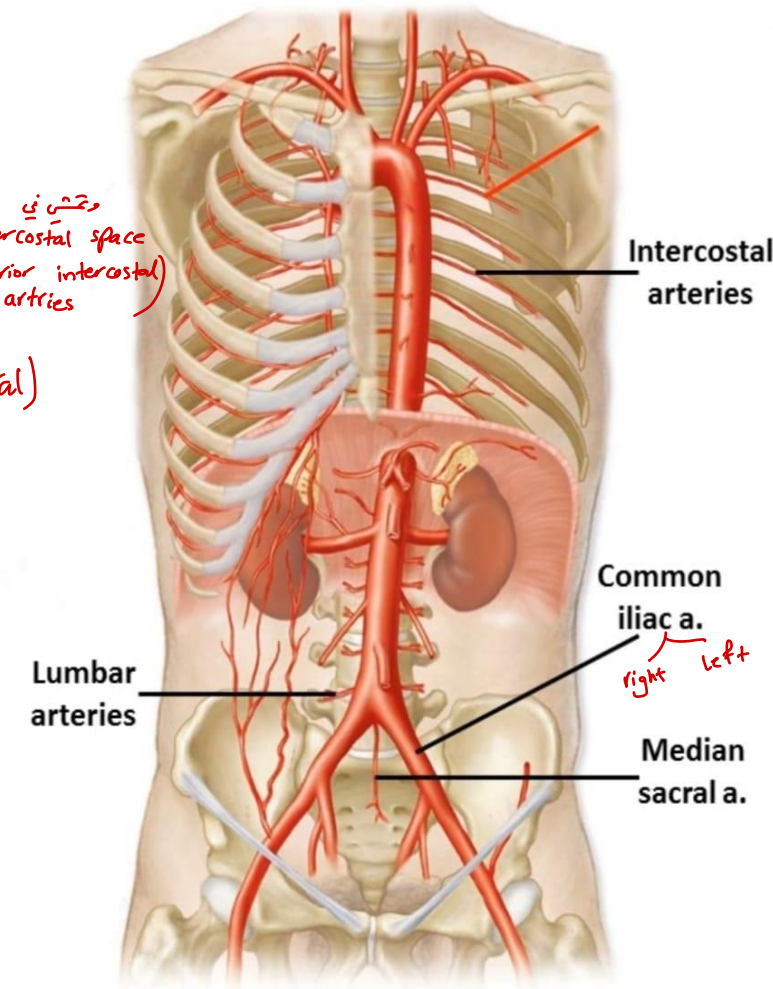
- All sacral: lateral sacral arteries. (Sacrum - راجع)

- Notice the median sacral artery.

Sacral intersegmental artery

Lateral sacral arteries ← راجع

middle line of the sacrum ← بـيـيـيـي



LATERAL SPLANCNIC ARTERIES:

They supply organs that were derived from intermediate mesoderm which are:

- the diaphragm
- kidneys
- suprarenal glands
- gonads



VENTRAL SPLANCHNIC ARTERIES

They form:

- Vitteline arteries which are:

1. Coeliac artery: supplies the foregut
2. Superior mesenteric artery: supplies the midgut
3. Inferior mesenteric artery: supplies the hindgut

- Umbilical arteries: their proximal parts will form the internal iliac arteries



mesoderm كاسم مقسم إلى
Intermediate Lateral plate Paraxial

(تغذي الأعضاء الموجودة بجانب الجسم)

Lateral splanchnic:

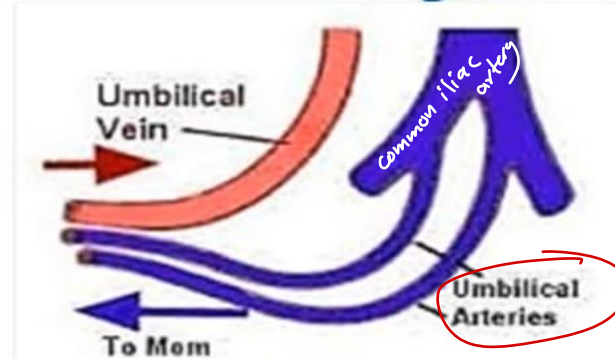
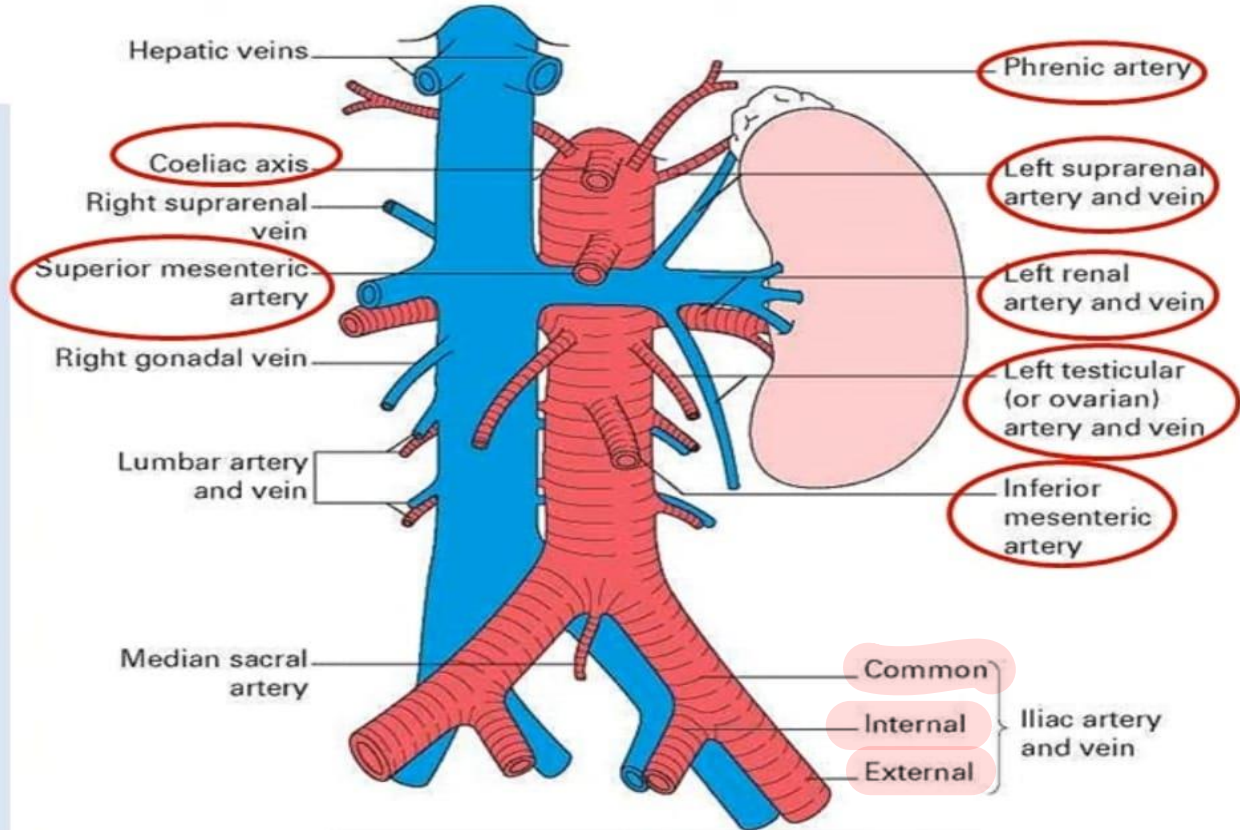
- Phrenic, renal, middle suprarenal, and gonadal arteries (to structures derived from intermediate cell mass mesoderm).

(تغذي الأعضاء الموجودة في البطن/الجسم من قدام)

Ventral splanchnic:

- A) vitelline: Coeliac, superior mesenteric, and inferior mesenteric arteries (to GIT).
- B) umbilical: their proximal parts will form the internal iliac arteries.

← راجع Placenta



umbilical Arteries

موصول في
common
iliac
artery
(dorsal aorta)

روح
internal
iliac artery



ANOMALIES OF THE ARTERIES

1. PATENT DUCTUS ARTERIOSUS:

It may occur alone or associated with coarctation of aorta

2. COARCTATION OF AORTA:

There is a narrow segment

It could be preductal or postductal

If it is preductal, the ductus remains patent

↓
يع
blood supply
صحة الحياة

في connection بين left pulmonary artery و arch of aorta على انماصة لبار
لأنه left 6th aortic arch ما احتضن لكنه right distal part
وهذا connection له ميزة مرفقة في fetal circulation عنه بدل ما يرجع على ايدم المتوسج للرئتين
يرجع لـ aorta عنه يغذي الجسم وبعد الولادة هذه ductus arteriosus لازم تسكر
وتحل ligamentum arteriosum

ولكنه ليه ما يمكن الطفل ينزل منها (ductus arteriosus) في حالة سبيتر ←

يعني aorta يكونه من segment
مكونة اوصفئة اكثر من segment ثانية
وذلك بسبب مشاكل في ايفصالات
والالياف تتبع جدار الوعاء

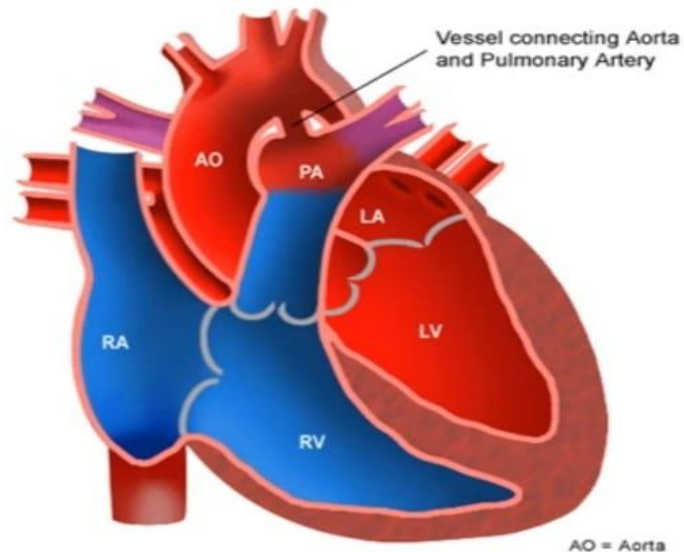


Anomalies of arteries

Patent Ductus arteriosus

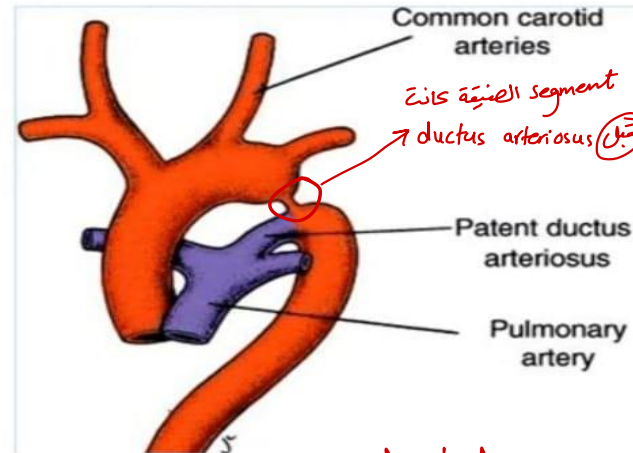
- May be alone or due to coarctation of aorta.

Patent Ductus Arteriosus (PDA)

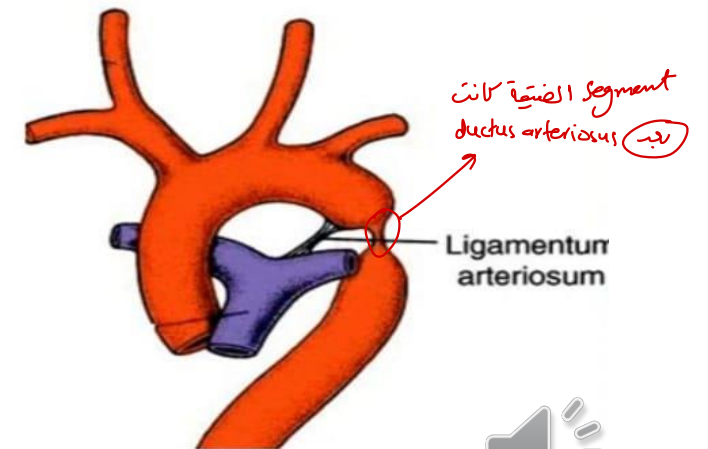


Coarctation of aorta

- It is **narrowing** of a **segment** of aorta.
- **Pre-ductal:** with PDA.
- **Post-ductal:** without PDA.



Pre-ductal
Coarctation
of Aorta



Post ductal
Coarctation
of Aorta



3. RIGHT AORTIC ARCH:

It is due to disappearance of the left dorsal aorta from left seventh segmental artery to the single dorsal aorta but that portion on the right side persisted

aortic arch بدل ما يكون على الناحية اليسار نبالا فيه على الناحية اليمنى

وكل شيء طبيعي ولكن معكوس والرب أنه بدل ما تختفي المنقطة بين

7th segmental artery & dorsal artery

على الناحية اليمنى

أصبحت في الناحية اليسار

4. DOUBLE AORTIC ARCH:

The right portion from the seventh segmental artery to the single dorsal artery did not disappear.

It can lead to difficulty in swallowing and breathing

بنسجيا
Vascular ring

لأن Trachea و esophagus
مضغوتيه مابين
هذه 2 arches
بالتالي

5. INTERRUPTED AORTIC ARCH:

Disappearance of both right and left fourth aortic arches

It is incompatible with life

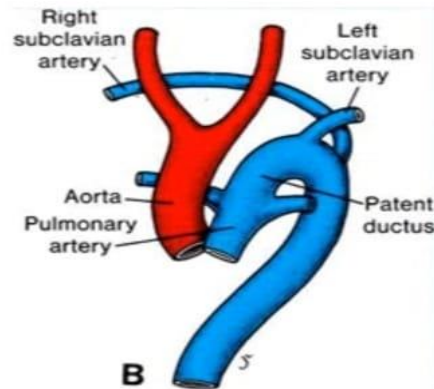
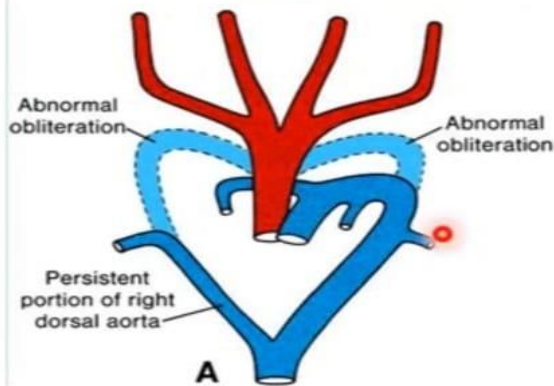
double aortic arch عكس

aortic arch لم يخلو أصلاً

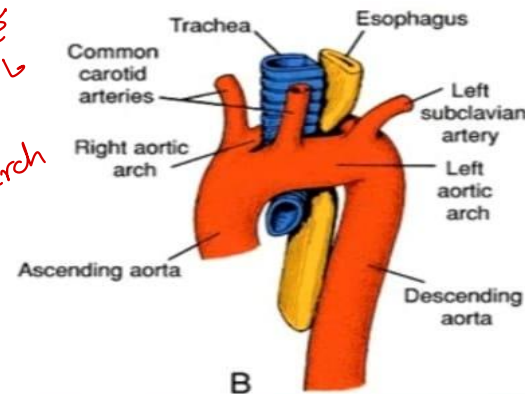
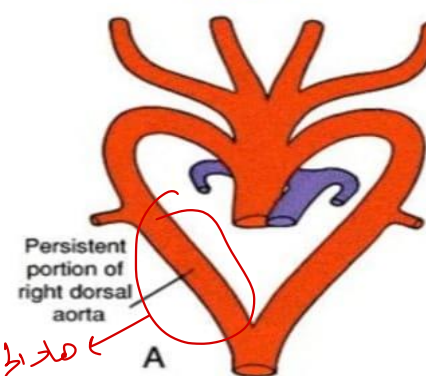


Anomalies of arteries

Patent Ductus arteriosus



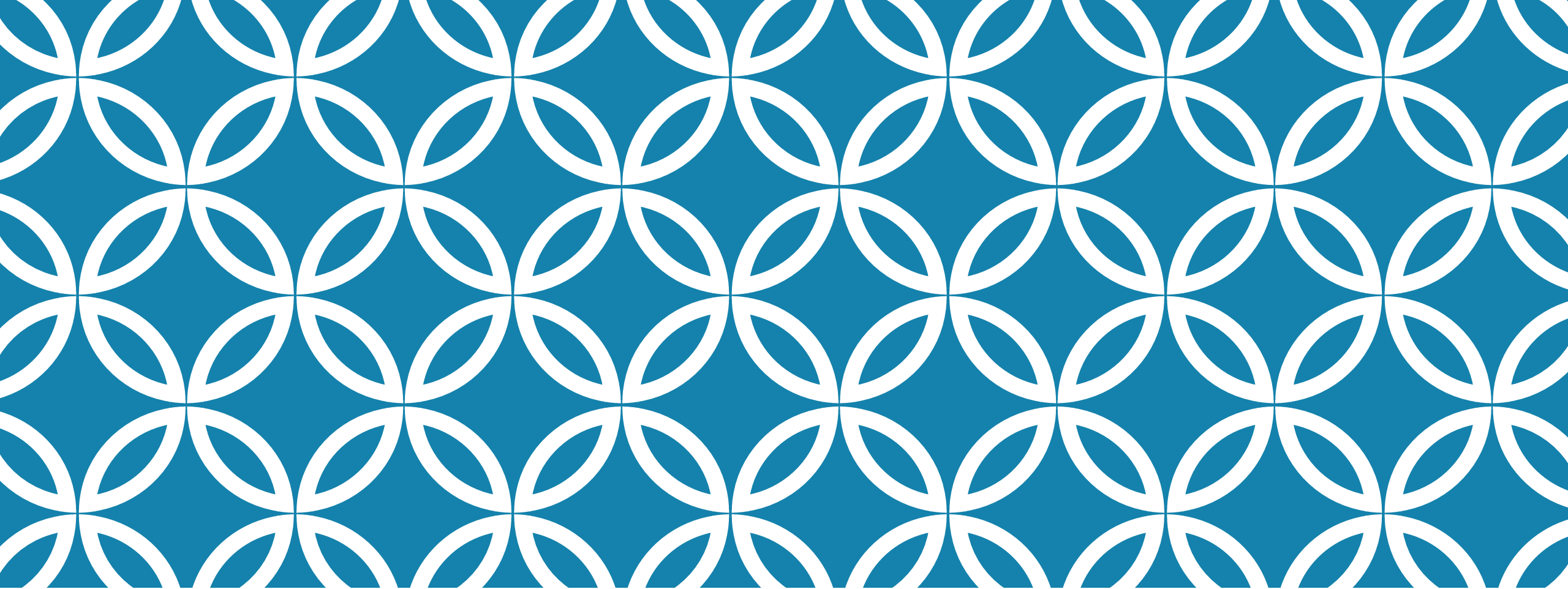
Coarctation of aorta



Aortic arch problems

- **Double aortic arch** (cause?).
- **Right aortic arch** (cause?).
- **Interrupted aortic arch** (cause?).

هذا الجزء كما المفروض
يحتوي ركة
ما اطلق فرغ
Double
aortic arch



CARDIAC EMBRYOLOGY 7

FETAL CIRCULATION

*Dr. Sawsan S.
Shurrah*

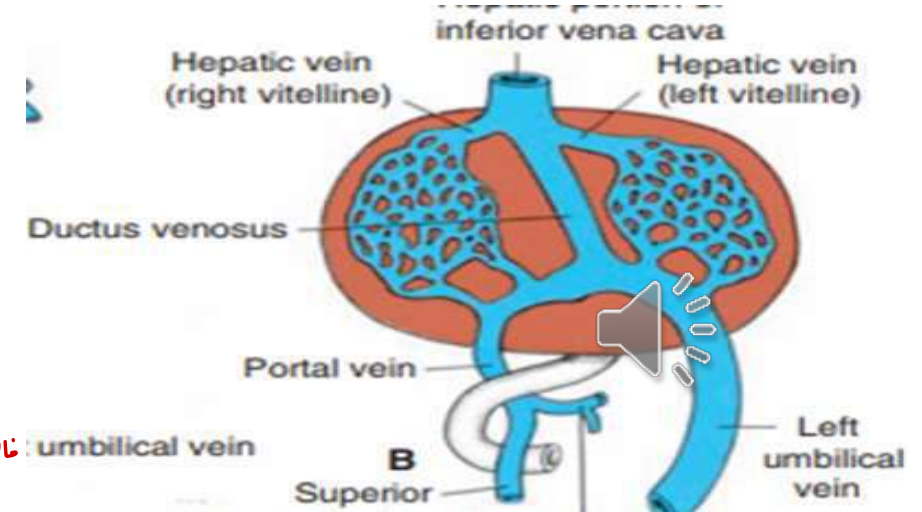


The source of highly oxygenated blood in fetus is left umbilical vein.

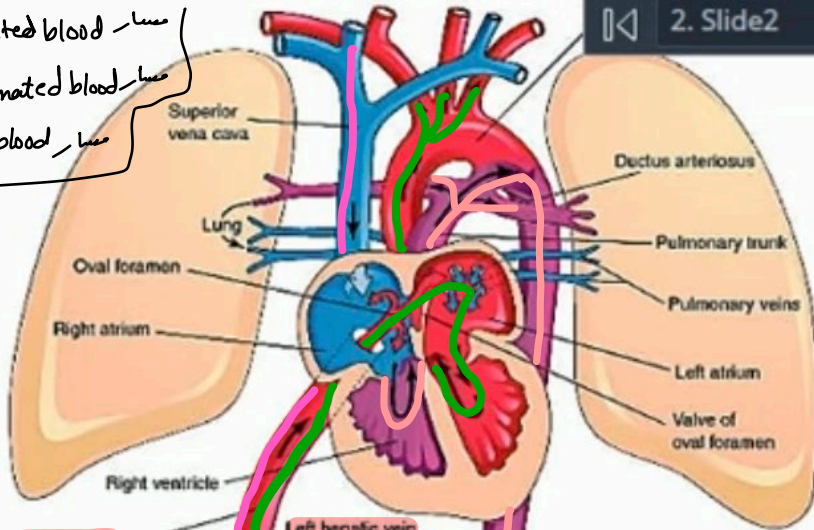
umbilical → 2 arteries
 → 1 vein → left umbilical vein
 vein → closure / obliteration

- Before birth, blood from the placenta 80% saturated with oxygen, returns to the fetus by **LT umbilical vein**.
- In the liver, most of the blood flows through ductus venosus directly into the inferior vena cava,
- A smaller amount enters the liver sinusoids and mixes with blood from portal circulation
- A sphincter mechanism in ductus venosus regulates flow of blood

يذهب الدم في الكبد
 ↓
 ductus venosus (المسار الأميني)
 vein
 IVC و umbilical vein
 liver sinusoids
 في حال صار uterus contraction ← يجرى الدم بانفتاح
 كبير ناحية الجنين (مارج يتجه heart of embryo)
 لذلك ductus venosus في هذه الحالة تنقبض (sphincter)
 فدم يتوجه إلى sinusoids فليختلص الضغط ويرجع ثانية إلى IVC ضغط أقل



→ oxygenated blood - **خضراء**
 → deoxygenated blood - **حمراء**
 → mixed blood - **بنفسجية**



Septum transversum - **منطقة تقعر الجوفاء الكبدية**
 liver

left umbilical vein

عمل Connection في

liver sinusoid مرتين

left branch of portal vein وتكونت شاة جديدة مباشرة
 IVC من left umbilical vein
 Ductus venosus

Portal vein

Umbilical vein

Umbilicus

هاد اتجاهه

liver sinusoid

يدخل فيه الدم من

فصله من قبله

الطفل عند صرورت

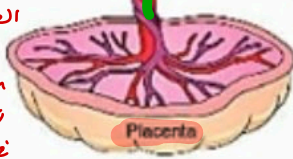
uterine

contraction

زنى ما صكتنا

في السلي

السابع



Placenta

Urinary bladder

Umbilical arteries

Lower limb

Internal iliac artery

Oxygen saturation of blood



High oxygen content



Medium oxygen content



Poor oxygen content

- This sphincter closes when a uterine contraction renders the venous return too high, preventing a sudden overloading of the heart.

- After a short course in the inferior vena cava, where placental blood mixes with deoxygenated blood returning from the lower limbs, it enters the right atrium.

(أي ~ IVC رج صلبا blood venous retain
 ~ lower limbs ف رج خيطة الدم التي حاي من الأم بالumbilical vein من ضلوا
 ~ ductus venosus ← IVC رج خيطة مع الدم الوماني من lower limbs (سنة، الخسبي رج نقل)

- Here, it is guided toward the oval foramen by the valve of the inferior vena cava, and most of the blood passes directly into the left atrium to the patent foramen ovale

Value الذي موجود فيه هو الذي رج يوجه الدم من رج
 (فحة IVC حايمة أمام فحة foramen ovale)



بعد ما يدخل الدم Right atrium عظم الدم مع يتجه إلى left atrium لعدة أسباب :-

① فتحة IVC مباشرة أمام فتحة foramen ovale

② حائل interatrial septum

Septum secundum نزل على عيب Septum primum فتحة تسمى valve
يجل تصبى للدم من right إلى left atrium

③ lungs of embryo من شغالة ← الدم الراجع منها + pressure رج يكونا مائل .
So pressure of right atrium higher than pressure in left atrium

mixed blood هذه تسمى نضية الجسم والأعضاء الغير مهمة من شغالة في الجنين

يحافظ على lungs عاليه .

- A small amount is prevented from doing so and remains in the right atrium ← جزء بسيط من الدم يبقى

Right atrium →

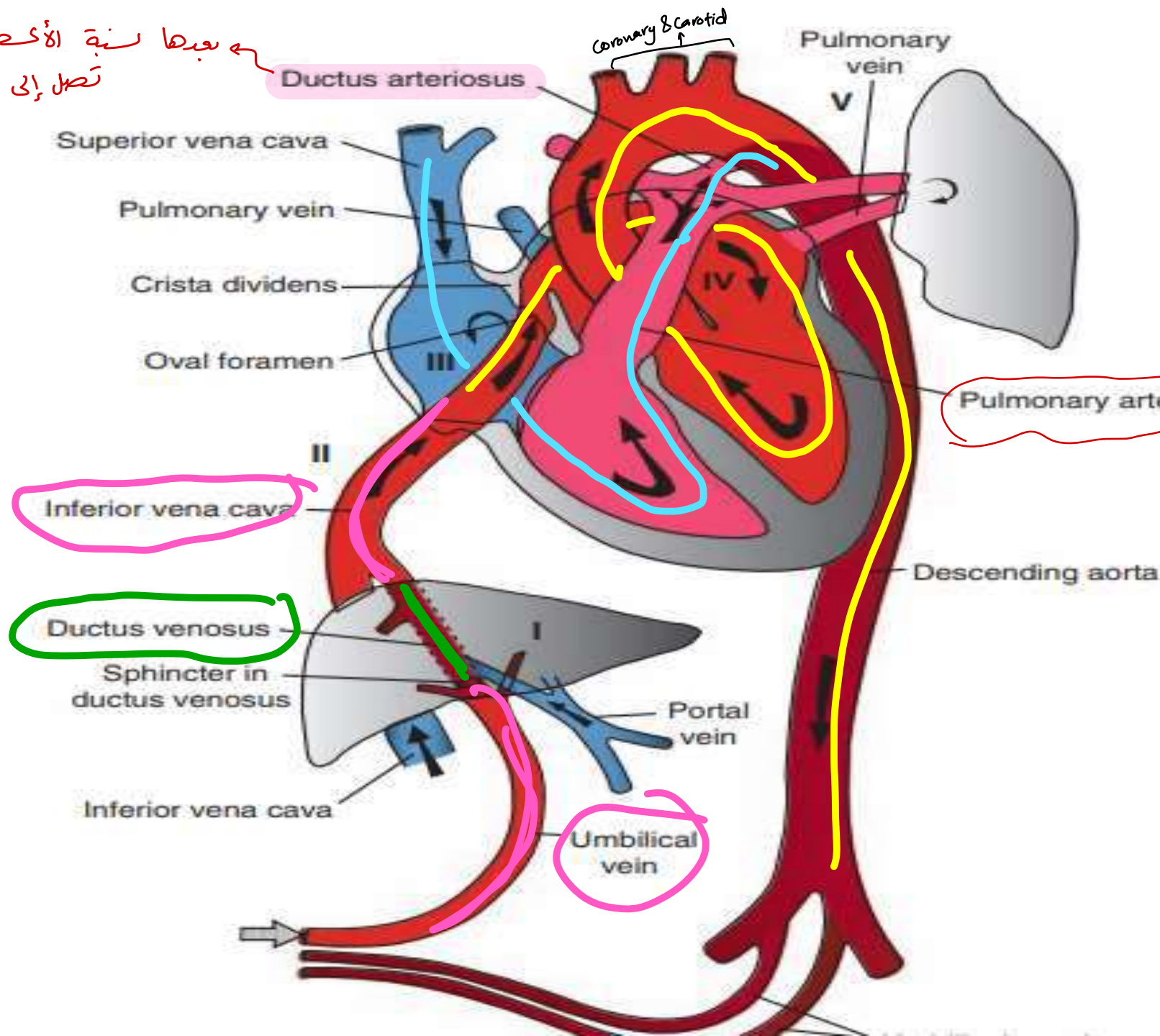
- Here it mixes with desaturated blood returning from the head and arms by way of the superior vena cava.

سوف يصيبه أيضاً
Pulmonary veins (deoxygenated blood ← تحمل قبل الولادة)

- From the left atrium, where it mixes with a small amount of desaturated blood returning from the lungs, blood enters the left ventricle and ascending aorta. → ذاك كل أفراد الجسم



بعداً نسبة الأوكسجين تنقل حصة
تصل إلى 58%



resistance تبقه عالي جداً في
intrauterine life

خالد منقاد يرسل إلى جزء
بسيط منه إلى pulmonary artery
أرنا معظم الدم سينصب إلى
aorta through the ductus arteriosus



- Since the **coronary** and **carotid** arteries are the **first branches** of the **ascending aorta**, the heart musculature and the brain are supplied with well-oxygenated blood.

- Desaturated blood from the superior vena cava flows by way of the right ventricle into the pulmonary trunk.

لـ ولفتر الطرفية شبه معدودة وراعي Truncus arteriosus

إلى aorta بعد ما كـ aorta أعلى

Coronary & Carotid

بالتالي الدم العاصل لـ heart & brain

يعني أنضد دم وأعلى نسبة

oxygen



- During fetal life, resistance in the pulmonary vessels is high, such that most of this blood passes directly through the ductus arteriosus into the descending aorta where it mixes with blood from the proximal aorta. →

دخول الأوكسجين
في aorta
تقل كثير.

- After coursing through the descending aorta, blood flows toward the placenta by way of the two umbilical arteries. →

كامل
Non oxygenated blood
to the mother
صوت تنقيت مركب نسبة الأوكسجين وارتجبا
للجنين عبر
umbilical vein

- The oxygen saturation in the umbilical arteries is approximately 58%.

oxygenated blood تحمل
Nonoxygenated blood تحمل

umbilical vein
umbilical artery

مقط



During its course from the placenta to the organs of the fetus, blood in the umbilical vein gradually loses its high oxygen content as it mixes with desaturated blood.

كل ما في الدم كل كل تركيز
الأكسجين فيه نتيجة خلطه مع
Non oxygenated blood
التي تصل إلى 58%

Theoretically, mixing may occur in the following places :

1. **In the liver** by mixture with a small amount of blood returning from the portal system;
2. **In the inferior vena cava** , which carries deoxygenated blood returning from the lower extremities, pelvis, and kidneys
3. **In the right atrium** by mixture with blood returning from the head and limbs.
4. **In the left atrium** by mixture with blood returning from the lungs (Non oxygenated)
5. At the entrance of the ductus arteriosus into the descending aorta .

جاي من SVC

Non oxygenated blood
طولة

right ventricle / Pulmonary artery
بجاية كبر ← جاي من



CIRCULATORY CHANGES AT BIRTH

- Changes in the vascular system at birth are caused by cessation of placental blood flow and the beginning of respiration.

انقطاع الحمل
السري

(أول نفث مع أول cry)

حالة حرجية لسبب الأكسجين (لوقت سبة) لا يحصل رج

- Since the ductus arteriosus closes by muscular contraction of its wall, the amount of blood flowing through the lung vessels increases rapidly.

تقلل ضغطاً لأنه

ينزل محبس لسبب

الأكسجين في الدم

بالتالي الدم لم يصب

أمانه إلا lungs

through pulmonary

arteries

This, in turn, raises pressure in the left atrium.

الدم الذي يرجع مع lungs رج يرجع ثاني إلى pulmonary veins

left atrium وهو oxygenated blood حالياً فالضغط يزداد في left atrium

في المقابل الضغط في right atrium رج يقل نسبياً لقطع الحمل السري (لا يوجد دم في left umbilical vein)

بالتالي حصل
equalization of
pressure between right
& left atrium



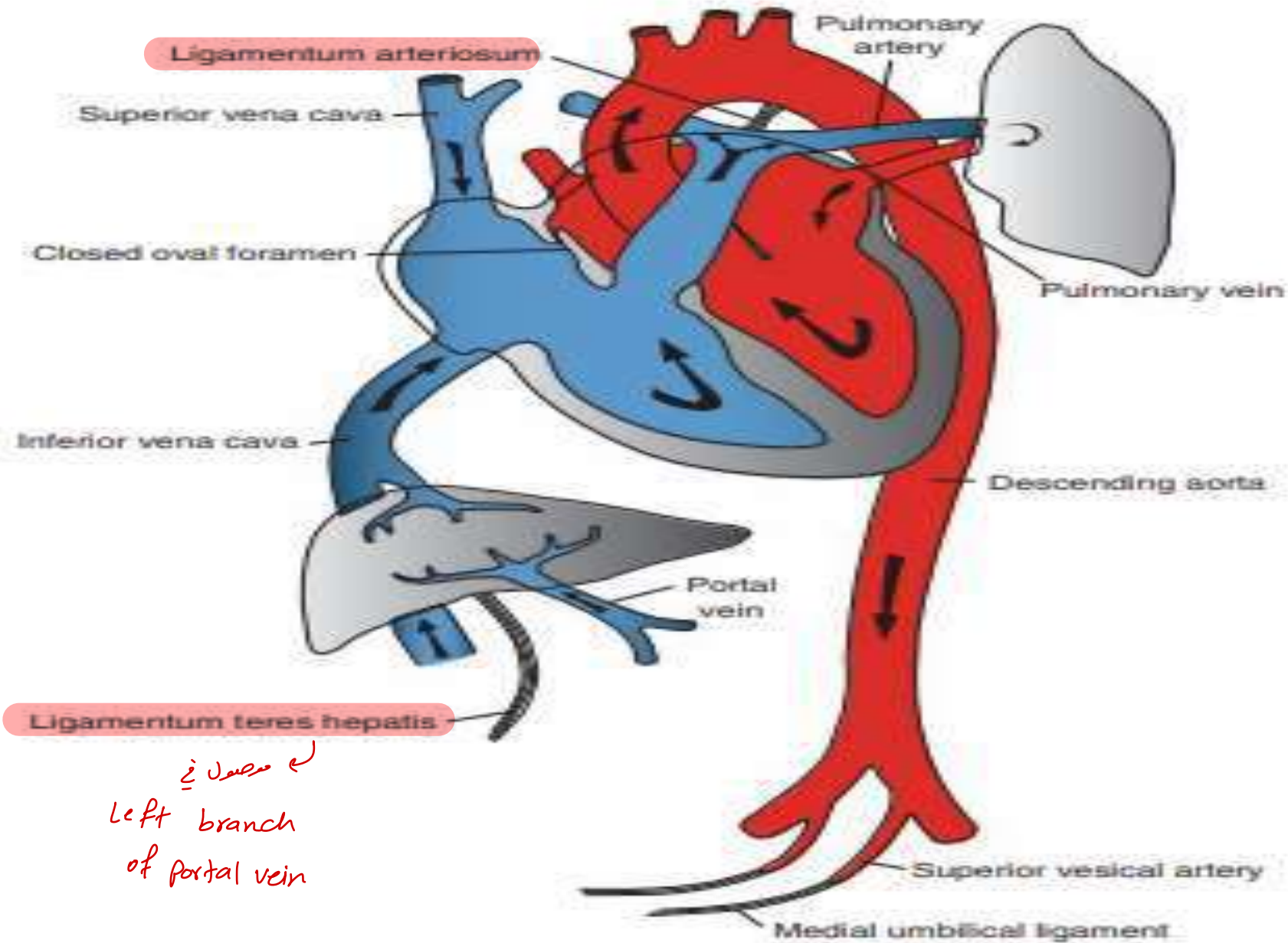
- Simultaneously, pressure in the right atrium decreases as a result of interruption of placental blood flow.

نسيجة لا سبغ

- The septum primum is then apposed to the septum secundum, and functionally, the oval foramen closes.

لـ مربع تبغى صغرة صغرة ثمها fossa ovalis (الموجودة في adult heart)





← موصول ہے
left branch
of portal vein



To summarize, the following changes occur in the vascular system after birth:

- Closure of the umbilical arteries, accomplished by contraction of the smooth musculature in their walls.



- Functionally, the arteries close a few minutes after birth, although the actual obliteration of the lumen by fibrous proliferation may take 2 to 3 months.

- Distal parts of the umbilical arteries form the medial umbilical ligaments, and the proximal portions remain open as the superior vesical arteries

لـ سبطاً blood supply
للـ bladder

Ligaments
موجودين على
جانبِ
umbilical
في
adult



Arteries تتركز بالأول وبعدها تتركز Veins عتاشيك نجي غرقة الولادة نبالقي الدكتور حاتقطع كبل
التي عاتول بخليه سقوة دقاته وبعدها تقطعه (عاتلي عكب سقوة دم زيادة من الأم للطفل) لأنه
umbilical vein حاسكر.

- Closure of the umbilical vein and ductus venosus occurs shortly after that of the umbilical arteries.
- Hence, blood from the placenta enter the newborn for some time after birth.



- After obliteration, the umbilical vein forms the **ligamentum teres** hepatis in the **lower margin of the falciform ligament**.
- The **ductus venosus**, which courses from the **ligamentum teres** to the inferior vena cava, is also obliterated and forms the **ligamentum venosum**



- Closure of the ductus arteriosus by contraction of its muscular wall occurs almost immediately after birth; it is mediated by **bradykinin**, a substance released from the lungs during initial inflation.
لـ مع أول نفث lung تبطلع ← bradykinin وهي المادة التي تكبر لد ductus arteriosus
- Complete anatomical obliteration by proliferation of the intima is thought to take 1 to 3 months
- In the adult, the obliterated ductus arteriosus forms the **ligamentum arteriosum**



- Closure of the oval foramen is caused by an increased pressure in the left atrium, combined with a decrease in pressure on the right side.
- The first breath presses the septum primum against the septum secundum.

During the first days of life, however, this closure is reversible.

لے مکہ لیب کا رجوع صغیر



- Crying by the baby creates a shunt from right to left, which accounts for cyanotic periods in the newborn.

لما يبكي بيزرعه ولكن لما ما يبكي ما بيزرعه ← اذنه طبيعي لأنه foramen ovale

ما سكر تماماً (نقطة مصدرة) بالتالي لما يبكي بيزرعه intrapulmonary pressure بالتالي ممكن يصير right to left shunt

- Constant apposition gradually leads to fusion of the two septa in about 1 year.

ممكن خلال 3 سنوات
يكون
complete closure

- In 20% of individuals, however, perfect anatomical closure may never be obtained (probe patent foramen ovale)

