



# CARDIOVASCULAR SYSTEM

SUBJECT : Anatomy

LEC NO. : Lecture 6

DONE BY : Gaith &ahmad afaneh

وَقُلْ رَبِّ زِدْنِي عِلْمًا



SCAN ME!

# Formation of the Interventricular Septum

The interventricular septum contain two parts:1) Muscular part 2)membranes part

- During the fourth week, a muscular median ridge arises from the floor of the primordial ventricle (Figs.11 and 18).

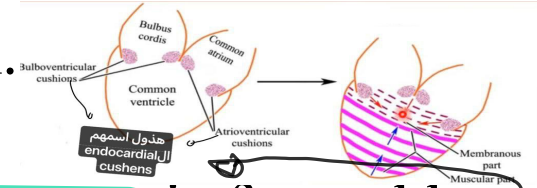
ال muscular part يبدأ النمو من الاسفل ثم يرتفع حتى يصل إلى نقطة التقائه مع ال membranes part

- The height of this muscular interventricular septum increases due to <sup>(1)</sup>growth of the right and left ventricles and <sup>(2)</sup>active proliferation of myoblasts in the septum.

- Until the seventh week, there is a crescent-shaped interventricular foramen between the concave free edge of the interventricular septum and the fused AV endocardial cushions. This foramen permits communication between the right and left ventricles.

قبل نهاية الأسبوع السابع يكون ال membranes part غير موجود وبيكون موجود محله ال interventricular foramen الذي يسمح لل Rt & Lt ventricles بالتواصل مع بعضهم البعض

- ❑ By the end of the seventh week, the conotruncal ridges fuse with endocardial cushions leading to the formation of a membranous septum that closes the interventricular foramen.



- ❑ The membranous part of the interventricular septum is formed by fusion of tissues from three sources: (1) right conotruncal ridge, (2) left conotruncal ridge, and (3) AV endocardial cushions.

- ❑ After closure of the interventricular foramen, the pulmonary trunk is in communication with the right ventricle and the aorta communicates with the left ventricle.

بعد الأسبوع السابع يبدأ تكوين فراغات في ال ventricular wall، مما يؤدي إلى تكوين ال trabeculae cornae

( rough part ) ، وتكوين ال papillary muscle

- ❑ Cavitation in the ventricular wall forms a spongy mass of muscular tissue, the *trabeculae carnae*. Some of them become prominent to form the *papillary muscles* (Fig.19).

# Formation of the Conotruncal Septum

- During the fifth week, two ridges appear in the truncus arteriosus: the right and left truncal ridges. As these ridges grow, they will spiral around each other.
- When the truncal ridges fuse, a spiral **aorticopulmonary septum** is formed (Figs.17 and 18). This septum divides the truncus arteriosus into two arterial channels, the ascending aorta and the pulmonary trunk.

ال conotruncal septum هي التي تتحكم في موقع ال pulmonary artery & aorta ، يعني  
ال aorta بتفتح على ال Left ventricle وال pulmonary trunk بتفتح على ال right ventricle

ال conotruncal septum قد تسبب

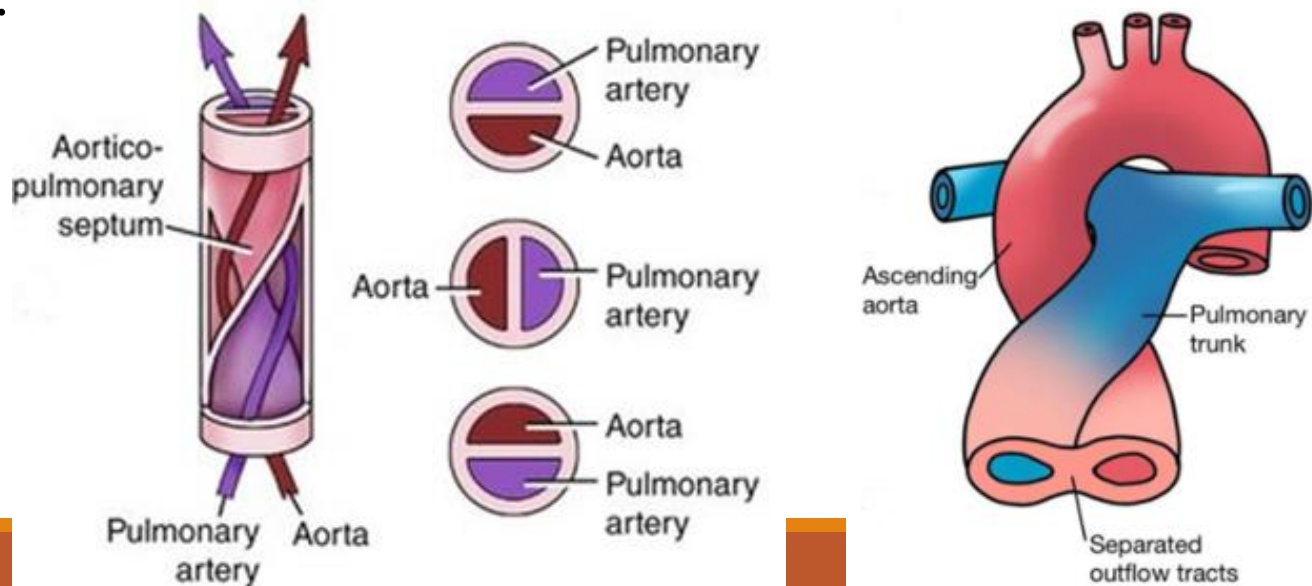
امراض مثل : transposition Of the

great vessels (يعني ال aorta بتفتح

على ال right ventricle، وال pulmonary

trunk بتفتح على ال left ventricle

Fig.17: The spiral aorticopulmonary septum.



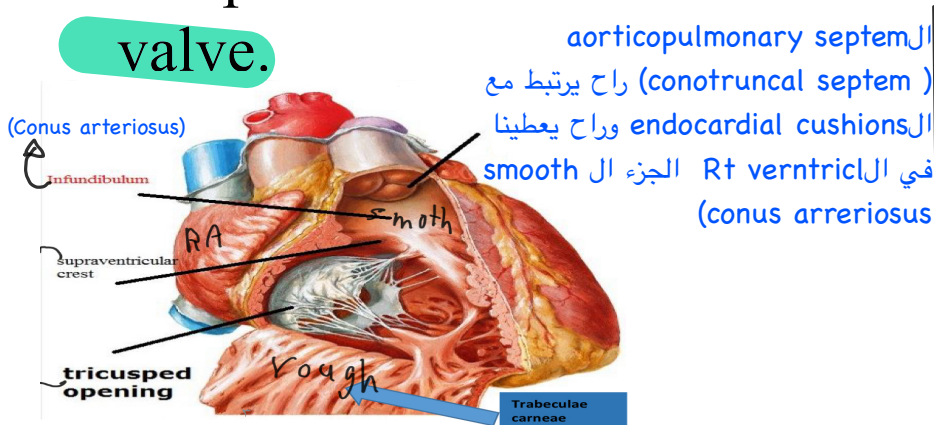


هذول ال ridges موجودين في ال conus Cordis and in the truncal arteriosus ، راح  
 يكونوا ال conotruncalridges الي راح تكون ال conotruncal septum

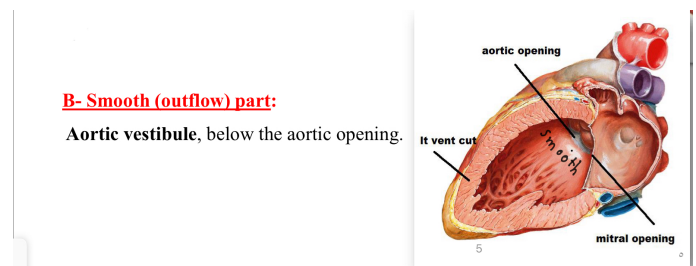
❑ Two similar ridges appear in the conus cordis. These fuse with each other and with the truncal ridges.

❑ When the two conal swellings have fused, the septum divides the conus into two portions:

1. The outflow tract of the right ventricle, the **conus arteriosus** (infundibulum), which is the origin of the pulmonary trunk.
2. The outflow tract of the left ventricle, the **aortic vestibule**, the part of the ventricular cavity just inferior to the aortic valve.



برضوا نفس الشيء راح يصير ال septum وال cushions راح يرتبطوا  
 مع بعض ويكونوا ال (aortic vestibule) smooth part ال Lt  
 ventricle



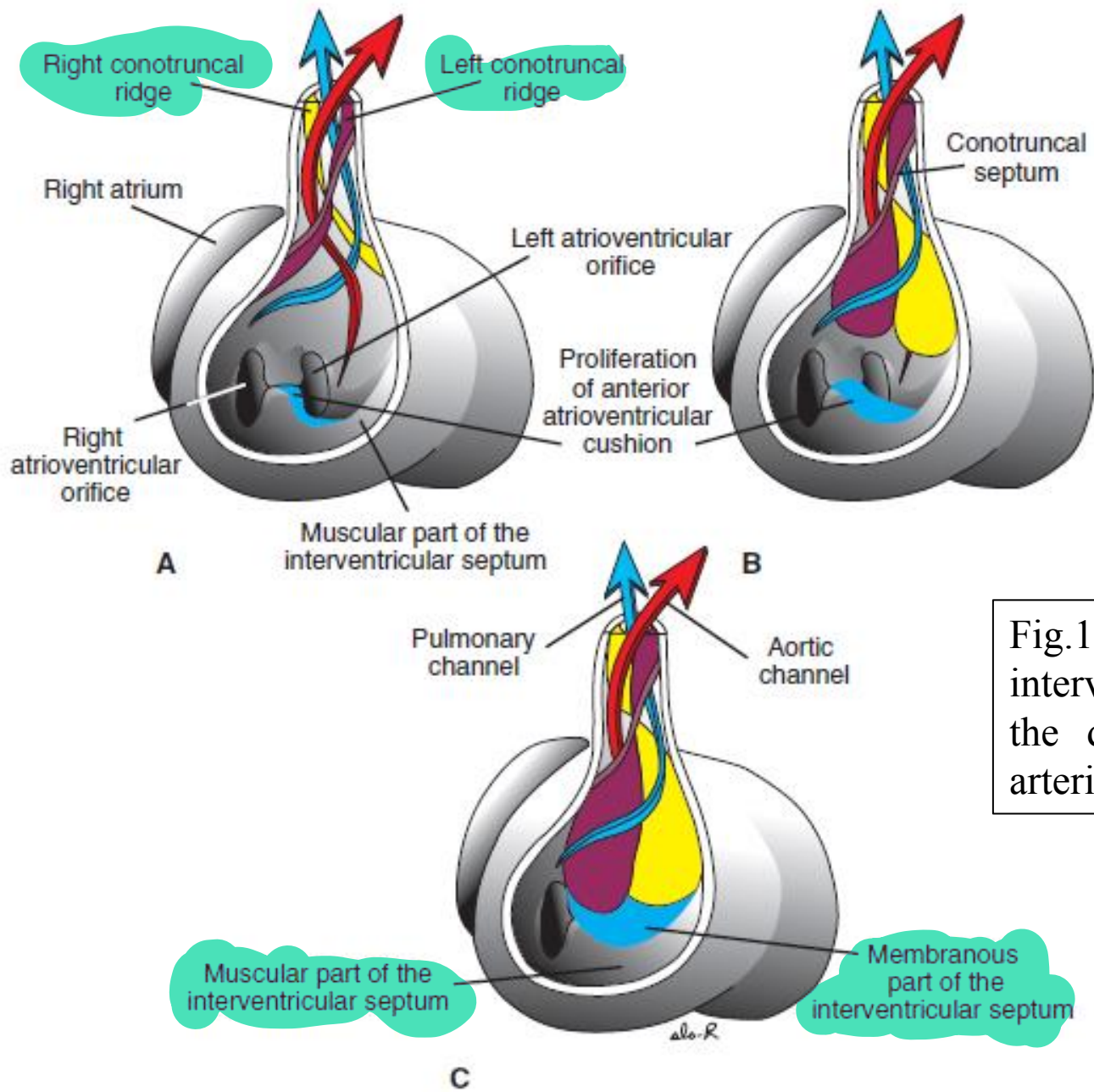


Fig.18: The formation of the interventricular septum and the division of the truncus arteriosus and conus cordis.

# Formation of the Cardiac Valves

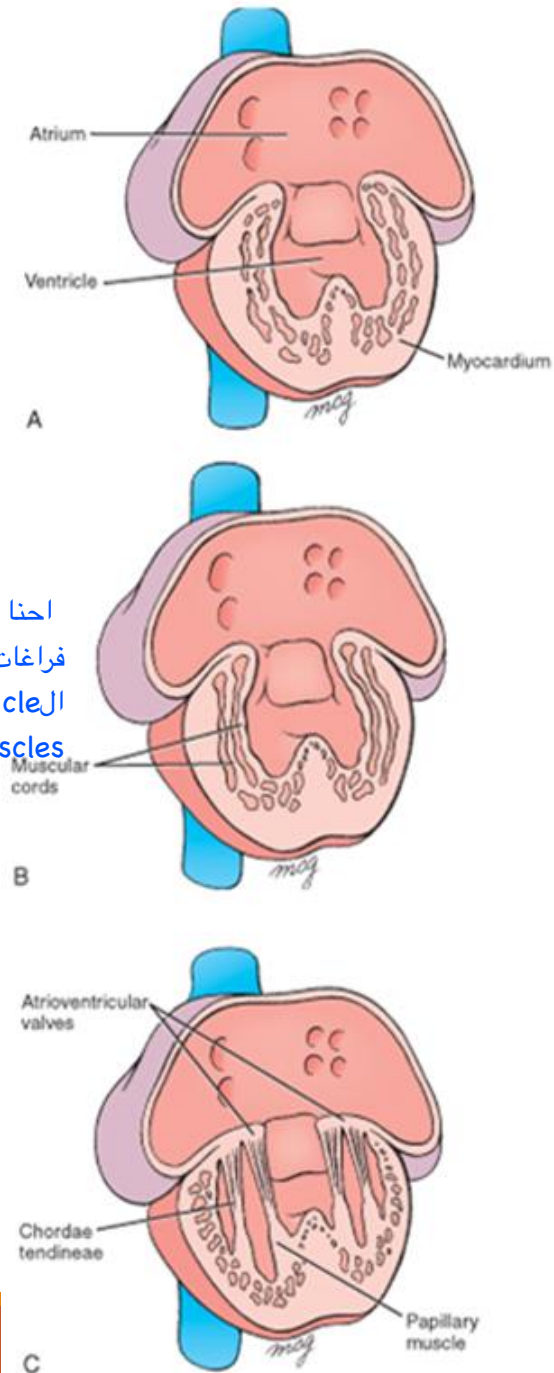
## The atrioventricular valves

- ❑ The ventricular surface of the AV endocardial cushions becomes hollowed out forming the thin cusps of the AV valves and the chordae tendinae, which attach the cusps to the papillary muscles

(Fig.19). احنا قلنا انه ال Av endocardial cushions راح يرتبطوا مع بعض ، وبعد ما يرتبطوا راح يصير فراغات في ال endocardial cushions (عشان راح يكون ال cusps) وراح يصير في فراغات في ال muscular part of ventricle (عشان يعطيني ال chordae tendinae وال papillary muscles)

- ❑ On the right side, there are three cusps forming the right atrioventricular (tricuspid) valve. On the left, we have two cusps forming the left (bicuspid, mitral) valve.

Fig.19: The formation of the atrioventricular valves. Note sponge-like appearance of the ventricular wall, these are the trabeculae carnae.



## The semilunar valves

هي الي راح تكون ال aortic و pulmonary valve  
، الvalve ، السلايد الجاي راح احكي كيف تكونوا

- ❑ After the formation of the aorticopulmonary septum, swellings appear at the orifices of both the aorta and the pulmonary artery (Fig.20).
- ❑ Gradually, the swellings become excavated on their upper surfaces to form the semilunar valves (three cusps for each valves).

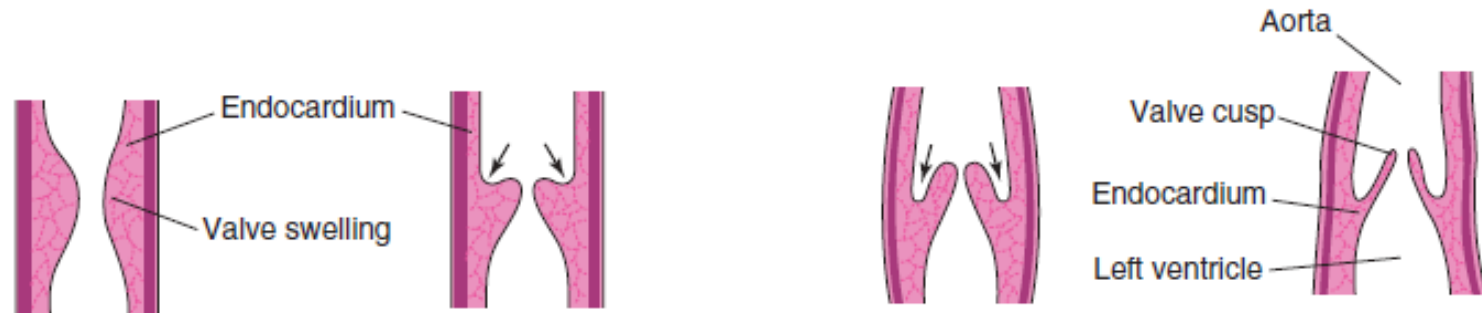
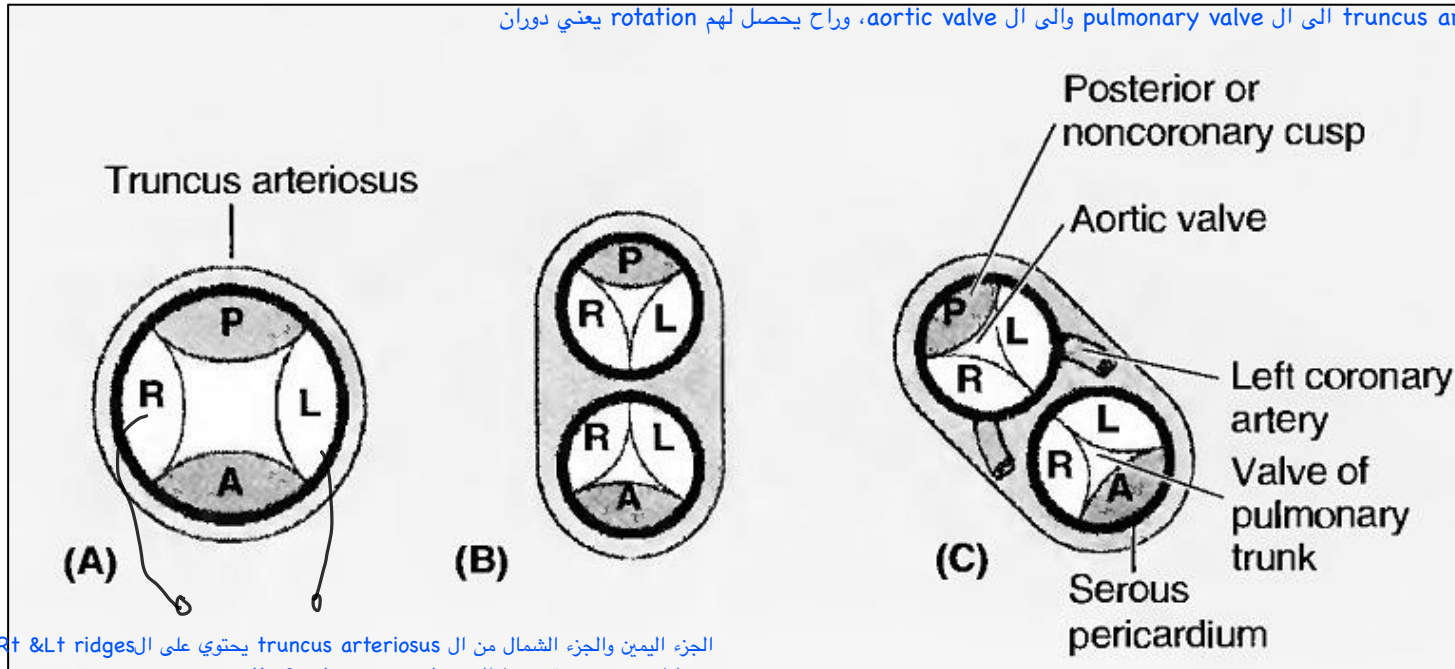


Fig.20: The formation of the semilunar valves.

الtruncus arteriosus راح يعطيني ال pulmonary trunk , وال ascending aorta من خلال ال pulmonary & aortic valves, بتكونوا من خلال : احنا قلنا انه ال truncus arteriosus بتحتوي على ال left & right ridges وهذول ال ridges راح يرتبطوا مع بعض ويكونوا ال conotruncal septum ويقسم الى الtruncus arteriosus الى ال pulmonary valve والى ال aortic valve. وراح يحصل لهم rotation يعني دوران



الجزء اليمين والجزء الشمال من ال truncus arteriosus يحتوي على ال Rt & Lt ridges راح يرتبطوا مع بعض ويقسموها الى aortic & pulmonary valve

Fig.21: The position of the cusps of the semilunar valves. R and L are the right and left truncal swellings, respectively. A and P are the anterior and posterior truncal swellings. After formation of the aorticopulmonary septum, the A and P swellings divide into two pairs, one for each artery. In later development (C), the truncus will rotate and the cusps will obtain their adult position.



# Development of the Vessels

ال blood vessels راح يتكونا بطريقتين :  
vasculogenesis(١) في ال mesoderm  
خلايا تتجمع وترتبط مع بعضها وتكون tubes  
angiogenesis (٢) هي عملية تصنيع tube  
من tube موجود، يعني في tube موجود عملنا  
فيه تفرع صار مرتبط فيه tube ثاني .

❑ Blood vessels are formed by two mechanisms:

1. **Vasculogenesis**. In addition to the **heart tubes**, two longitudinal tubes are formed by vasculogenesis on each side of the embryo's midline dorsally; these are called the **right and left dorsal aortae** (Fig.4). As lateral folding of embryo occurs, the two dorsal aortae fuse caudally to form a single midline dorsal aorta (Figs.5c). Cranially, the right and left dorsal aortae remain separate. The **cardinal veins** are also formed by vasculogenesis.

عنا ثلاث blood vessels بنصنعوا بطريقة ال vasculogenesis هم : (١) heart tube(٢) right & left dorsal aortae الي راح يرتبطوا مع بعض وراح يكونوا (٢) medline dorsal aorta cardinal veins ، اما باقي ال blood vessels ينصنعون عن طريق ال angiogenesis

2. **Angiogenesis**, by which new vessels arise from existing vessels.  
All other vessels in the body are formed by angiogenesis.

# Development of the Arterial System

- ❑ The dorsal aortae are related to three groups of arteries (Fig.23):
1. **Aortic arches.** These pass through the developing pharyngeal arches and connect the right and left dorsal aortae to the aortic sac.
  2. **Intersegmental arteries.** These are 30 paired branches of the dorsal aortae that supply the somites.
  3. **Splanchnic arteries.** Lateral and ventral branches that supply various organs of the body.

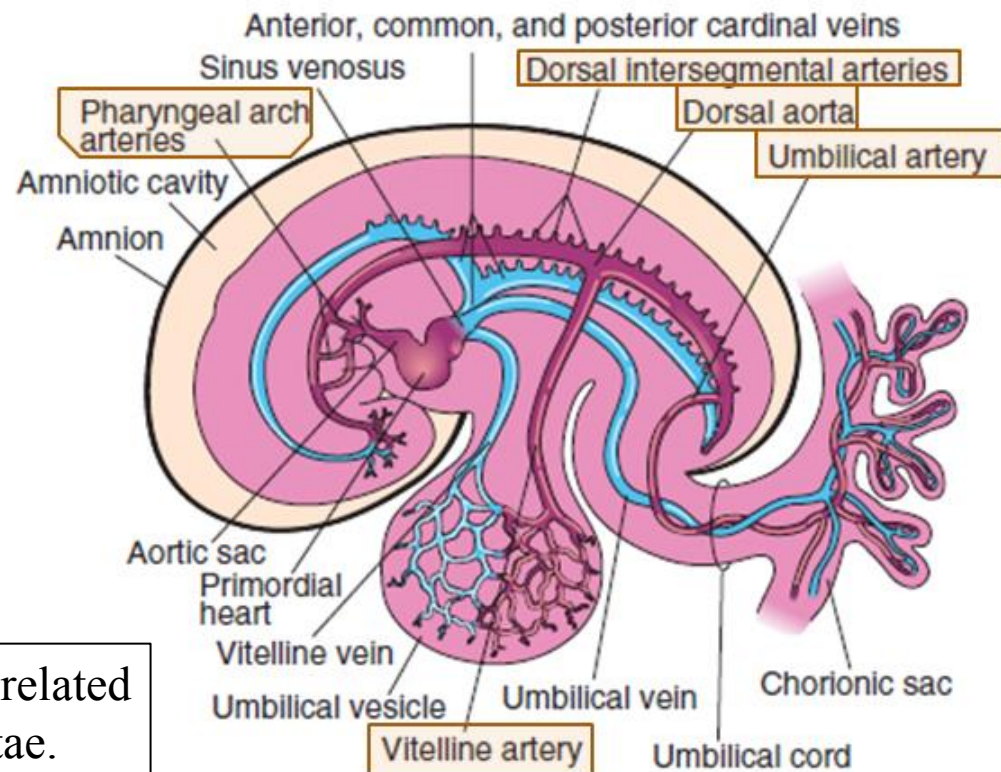
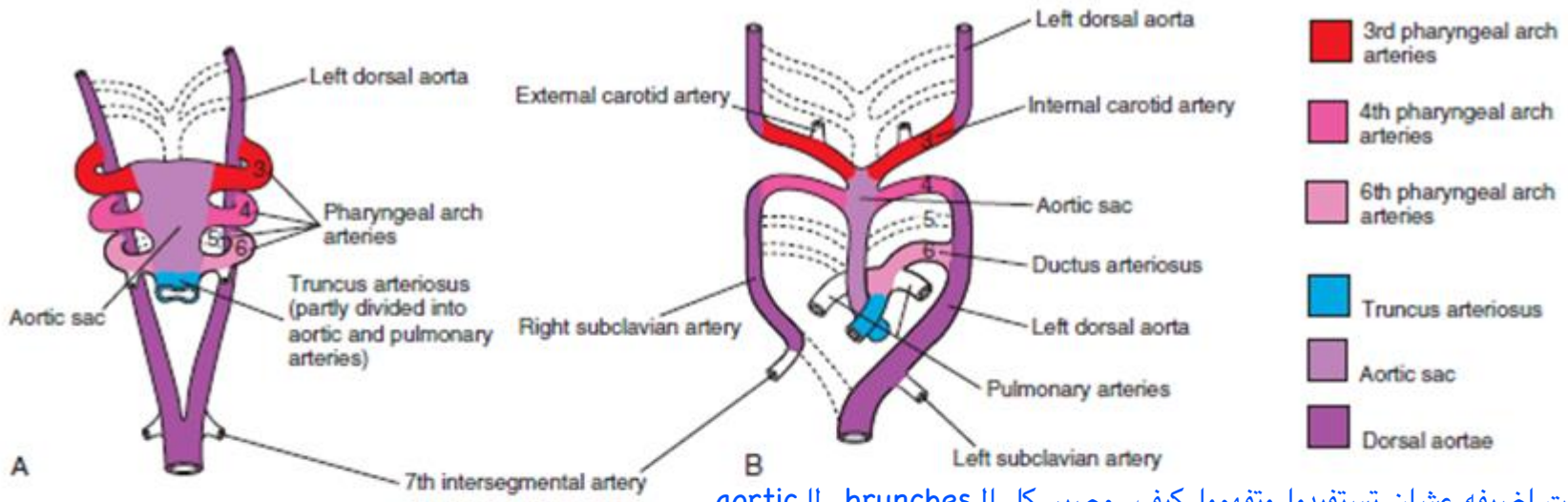


Fig.22: Arteries related to the dorsal aortae.

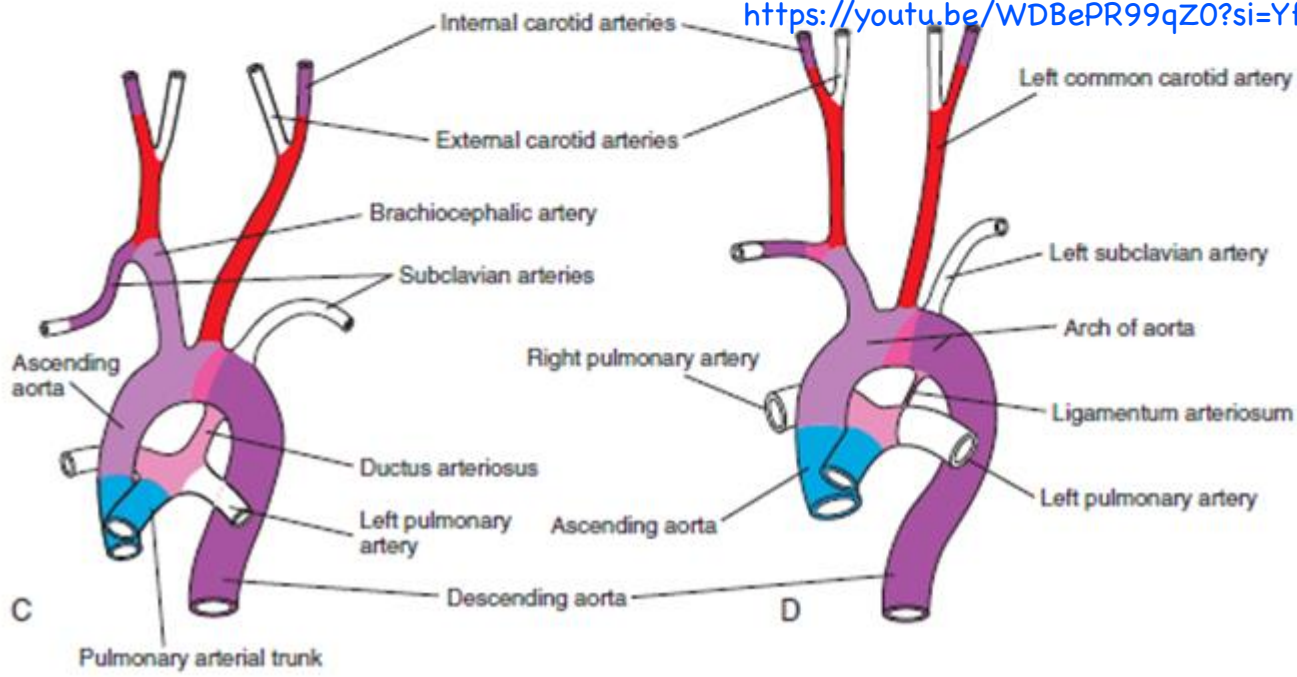
# The Aortic Arches

ال aortic arches يتكون من ١) dorsal aortae Rt & Lt ( التي لما بيكبروا يلتقوا على بعضهم ويرتبطوا مع بعضهم البعض ويكونوا ال aortic sac (٢) بتعطي 6 branches ( at each side ) وال 5th branch يختفي في فترة مبكرة من ال embryo (الجنين)، وهذا يمتد لل head وال neck وال thorax عشانه

- ❑ As the pharyngeal arches form during, they receive their own blood supply through the aortic arches which connect the aortic sac to the dorsal aortae.
- ❑ The arches appear in a cranial-to-caudal sequence, thus not all the aortic arches appear at the same time.
- ❑ Six arterial arches appear. The fifth arch, however, soon disappears (or may never form at all).
- ❑ The aortic arches give rise to various vessels in the thorax, neck, and head (Fig.23).



هذا السلايد حبيت اضيفه عشان تستفيدوا وتفهموا كيف مصير كل الbranches للأortic arches، لأنه الدكتور مختصر كثير منه ، هي شرح احمد كمال الهايا ريت تحضروا  
[https://youtu.be/WDBePR99qZ0?si=Yfyf\\_dTXoQEF817I](https://youtu.be/WDBePR99qZ0?si=Yfyf_dTXoQEF817I)  
<https://youtu.be/>



**Aortic arches**

6 pairs of arteries (aortic arches), each one belongs to one of the 6 pharyngeal arches.  
 -Each aortic arch extends between the **aortic sac** (dilatation at the upper end of the ductus arteriosus) to the dorsal aorta.

**Fate of the aortic arches**

- 1<sup>st</sup> arch disappears (leaving maxillary artery)
- 2<sup>nd</sup> arch disappears (leaving stapedial artery)
- 3<sup>rd</sup> arch gives carotid arteries:
  - External carotid arises as a new branch from the 3<sup>rd</sup> arch.
  - Proximal to the external carotid the 3<sup>rd</sup> arch gives the common carotid artery
  - Distal to the external carotid the 3<sup>rd</sup> arch gives the internal carotid artery
- 4<sup>th</sup> arch on the right side: it gives the proximal part of subclavian artery. On the left side it gives part of the arch of the aorta.
- 5<sup>th</sup> arch disappears
- 6<sup>th</sup> arch: The proximal part of each side gives the corresponding (right or left) pulmonary artery. The distal part of the right side disappears. The distal part of the left side forms the ductus arteriosus.

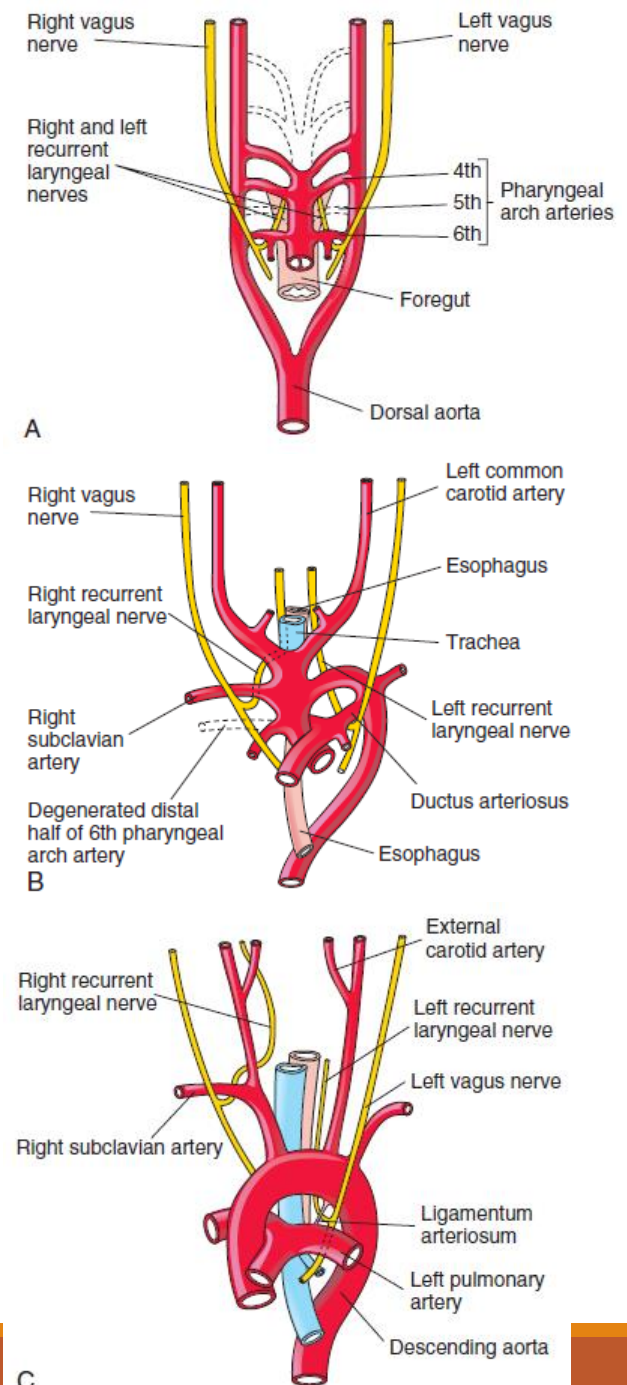
Fig.23: Various stages in the development of the aortic arches.



## Clinical Correlation

- The recurrent laryngeal nerve hooks around the 6<sup>th</sup> aortic arch.
- On the right side, the distal part of the 6<sup>th</sup> arch and the 5<sup>th</sup> arch disappear. The nerve becomes hooked around the 4<sup>th</sup> aortic arch.
- On the left, the whole 6<sup>th</sup> arch remains and the nerve becomes hooked around the ductus arteriosus.
- Because of this, when the adult derivatives of the arches are formed, the recurrent laryngeal nerve hooks around the subclavian artery on the right and the ligamentum arteriosum on the left.

Fig.24: Relation of the recurrent laryngeal nerve to the aortic arches.



C



# The Intersegmental Arteries

عنا احنا 30 pairs of  
intersegmental arteries مقسمين الى  
اجزاء مثل ال (cervicle) neck وال  
thorax وال lamber & sacral

- ❑ Thirty branches of the dorsal aorta that carry blood to the somites and their derivatives.  
الintersegmental artery الي موجودين في الneck راح يكونوا (7) , اول (6) راح يتجمعوا على بعضهم البعض ويكونوا (vertebral artery) one longitudinal artery مرتبط مع ال7th (هذا ال7th راح يكون subclavian artery, وهي الوحيدة الي راح تظل مرتبطة مع الdorsal aortae) والonelongitudinal راح ينفصلوا عن الdorsal aortae
- ❑ The arteries in the *neck* (the first 6) join to form a longitudinal artery on each side that is attached to the 7<sup>th</sup> intersegmental artery. This longitudinal artery will form the *vertebral artery*. The original connections of the arteries to the dorsal aorta disappear (Fig. 25).  
بكونوا موجودين في الthorax على اسم
- ❑ In the *thorax*, the intersegmental arteries persist as the *intercostal arteries*.
- ❑ The lumbar and sacral intersegmental arteries form various arteries in those regions.

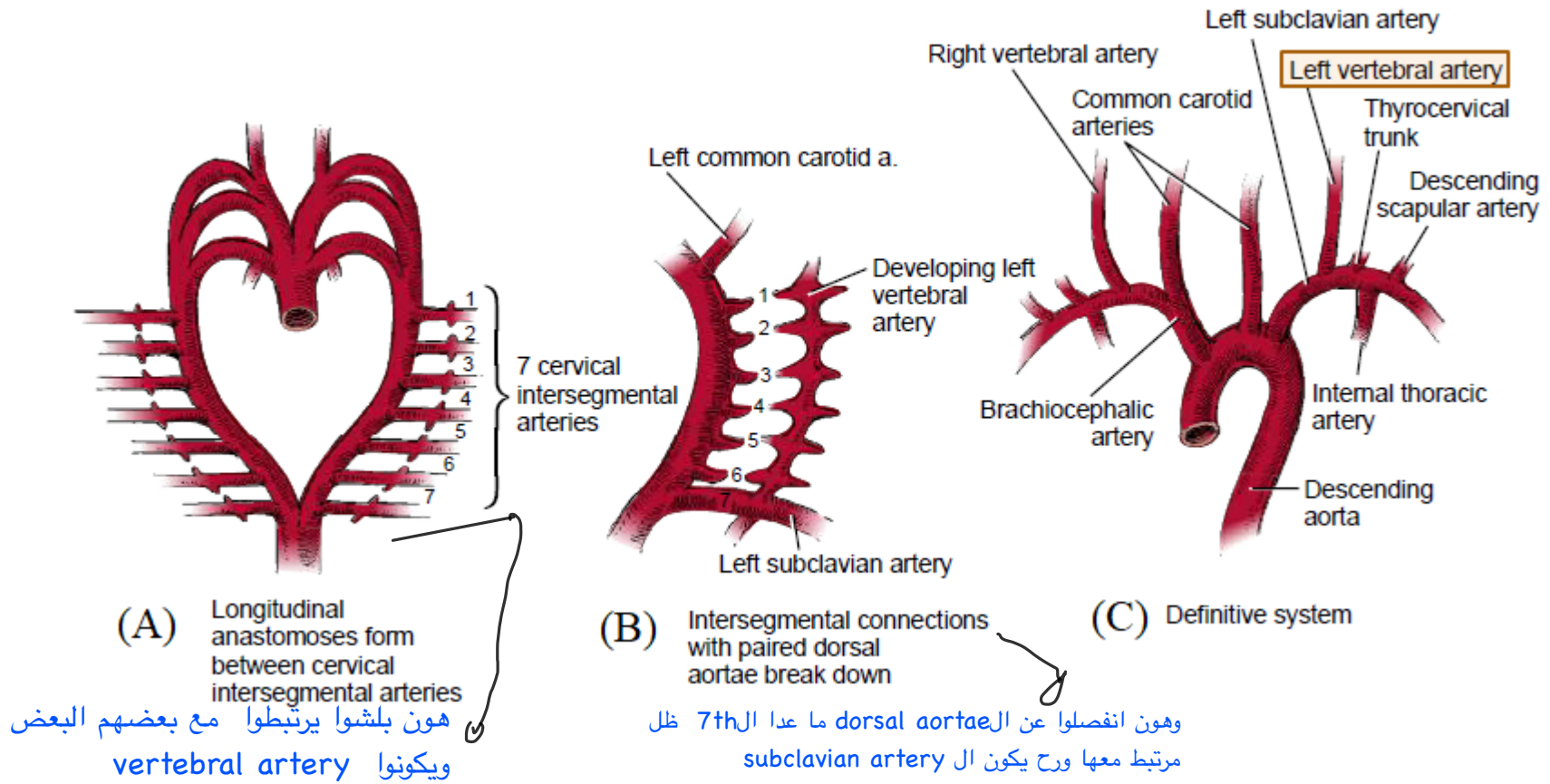


Fig.25: Development of the vertebral artery from the cervical intersegmental arteries. Notice in (C) how the vertebral artery is a branch of the subclavian.

# Splanchnic Arteries

- ❑ The *vitelline arteries* pass to the umbilical vesicle and later to the primordial gut. Most of these arteries fuse to form three single ventral branches of the aorta: the *celiac trunk*, the *superior mesenteric artery*, and the *inferior mesenteric artery*.
- ❑ The paired *umbilical arteries* pass ventrally through the connecting stalk (primordial umbilical cord) and become continuous with vessels in the chorion. Soon these arteries will lose their connection to the aorta and become connected to the common iliac arteries. The proximal parts of these arteries become the *internal iliac* and *superior vesical arteries*. The distal parts of the umbilical arteries become modified and form the *medial umbilical ligaments*.
- ❑ *Lateral splanchnic branches* form the *phrenic, suprarenal, renal, and gonadal* arteries.

ال lateral splanchnic هي التي تغذي الأحشاء الموجودة على جانبي الجسم ، مثلا  
phrenic) التي تغذي ال(Rt&Lt loop of the diaphragm) , والrenal (بتغذي الRt & Lt

(Kidney) , وال suprarenal (بتغذي الRt&Lt suprarenal gland) , وال gonadal (بتغذي

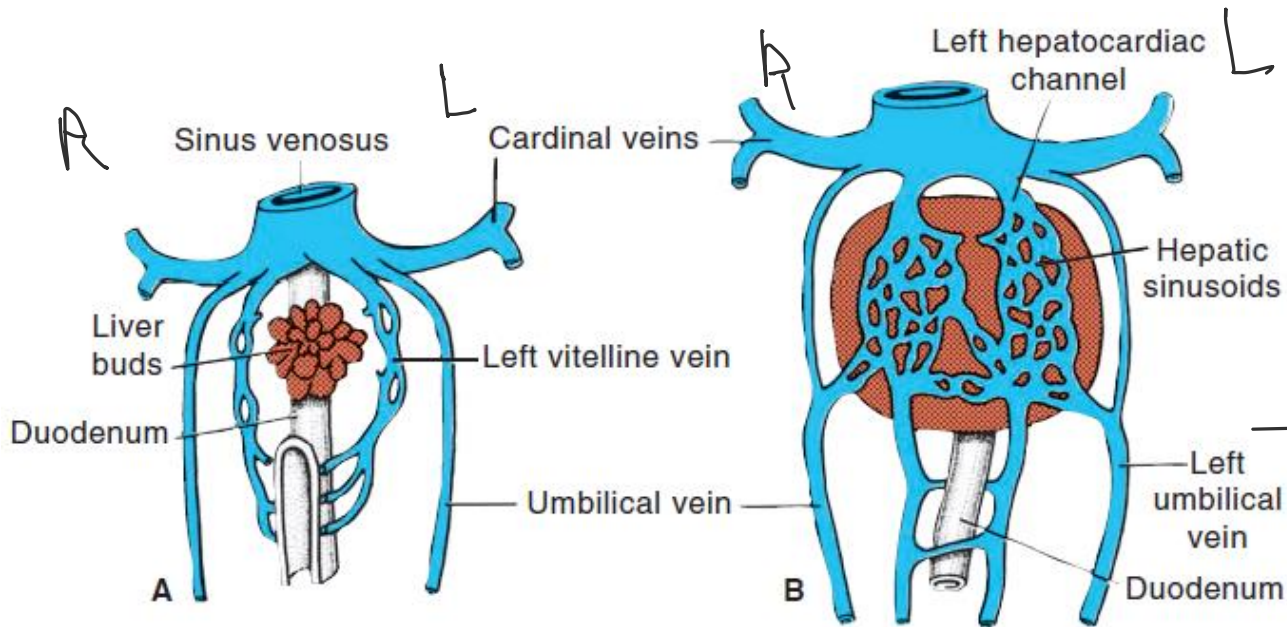
# Development of the Venous System

- ❑ The heart receives venous blood through 3 pairs of veins: (1) vitelline veins, (2) umbilical veins, and (3) common cardinal veins (Fig.13).
- ❑ Later in development, two more venous systems develop: (1) supracardinal and (2) subcardinal.
- ❑ Venous anastomoses are formed between the right and left sides of these systems and between each other.
- ❑ Most of the veins on the left will disappear and venous blood is shifted to the right side.

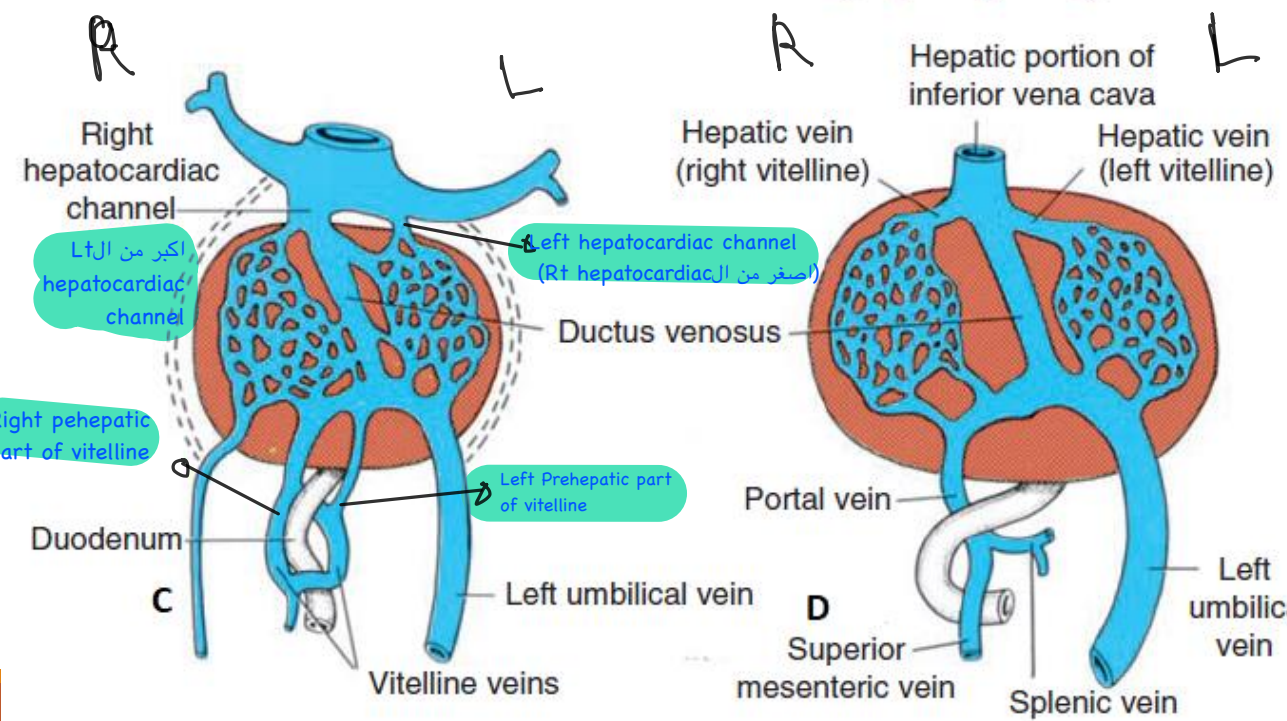
## Vitelline Veins

- ❑ The right and left vitelline veins carry deoxygenated blood from the umbilical vesicle and later the gut tube. They form a plexus around the duodenum (Fig.26a), then pass through the septum transversum before entering the sinus venosus. خلال نمو الجسم ال vitelline veins راح تكون موجودة داخل ال الكبد وراح تتكون ال liver sinusoids وبالتالي ررح يصير اسمها hepatocardiac channels داخلة في ال sinus venosus
- ❑ As the liver grows in this region, it will interrupt these veins leading to the formation of a network of venous spaces, the *hepatic sinusoids*, which are drained through the right and left *hepatocardiac channels* into the sinus venosus (Fig.26b).
- ❑ With reduction of the left sinus horn, the left hepatocardiac channel will become smaller and form the *left hepatic vein*. The prehepatic part of the left vitelline vein will disappear (Fig.26c,d).
- ❑ The right hepatocardiac channel will enlarge and form the *right hepatic vein* and the *terminal part of the inferior vena cava*. The prehepatic part of the right vitelline vein will form the *portal vein* (Fig.26d).





برضوا خلال النمو بسبب تقلص الـ left sinus horn, راح تتقلص ايضاً الـ left hepatocardiac channel يجعلها اصغر من الـ Right hepatocardiac, وراح تكون الـ hepatic vein, والـ prehepatic part of vitelline راح يختفي



هسا العكس في الـ right side, راح بتكبر الـ right sinus horn وكمات بتكبر الـ right hepatocardiac channel وتصير اكبر من الـ Lt hepatocardiac ري ما احنا ملاحظين الشكل (C) وتشارك في تكوين الـ inferior vena cava, وراح الـ prehepatic part of vitelline تكون الـ portal vein

Fig.26: Development of the portal circulation from the vitelline veins.

تتواصل مع الكبد من خلال الـ ductus venosus

# Umbilical Veins

الumbilical veins جاي من الplacenta يعني بجيب  
الoxygenated blood from placenta

- ❑ The right and left umbilical veins carry well-oxygenated blood from the placenta. They pass through the septum transversum to drain into the sinus venosus.

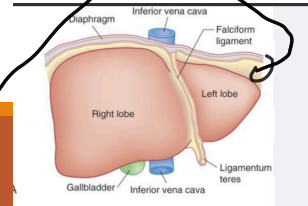
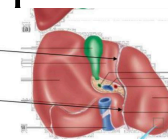
في البداية الumbilical veins موجودين على جنب الكبد ويتواصل معها بشكل بسيط، لكن مع النمو الجزء الأيمن من الumbilical vein راح يختفي ، والجزء الشمال راح يكون متصل مع الكبد من خلال ال (ductus venosus) كما موجود في الرسمة في السلايد الي قبل

- ❑ Initially, the umbilical veins pass on each side of the liver, with some connections to the hepatic sinusoids (Fig.26a,b).
- ❑ With further development, the entire right umbilical vein and the cranial part of the left umbilical vein disappear. The caudal part of the left vein persists becoming the only vessel to carry blood from the placenta to the liver (Fig.26c,d).
- ❑ A direct communication forms between the left umbilical vein and the right hepatocardiac channel, the *ductus venosus* (Fig.26d).

بعد الولادة بعد نقطع الLeft umbilical vein راح يتحول الى ligamnetum teres والى ligamnetum venosum الموجودين في الكبد ، وين

- ❑ After birth, the left umbilical vein and the ductus venosus will form the *ligamnetum teres* and *ligamentum venosum*, respectively.

■ Ligamentum teres  
hepatis  
■ Ligamentum  
venosum



# Cardinal Veins

اسمها الثاني somatic veins يعني بتجيب الveins من  
الbody كله , احفظوه الموجود هون غير هيك مش مطلوب

- ❑ These carry deoxygenated blood from the body of the embryo.
- ❑ The anterior and posterior cardinal veins carry blood from the cranial and caudal parts of the embryo, respectively. They unite to form the common cardinal veins which open into the sinus venosus.
- ❑ An *oblique anastomosis* is formed between the anterior cardinal veins that shunts the blood from the left to the right. This shunt will form the *left brachiocephalic vein*. The *anterior cardinal veins* will form the *internal jugular veins*. The *right common cardinal and part of the right anterior cardinal veins* will form the *superior vena cava (SVC)*.  
الposterior cardinal vein راح يختفي وراح بتبدل بال  
supracardinal & subcardinal veins
- ❑ The *posterior cardinal veins* will largely disappear.
- ❑ The *supracardinal* and *subcardinal* veins will form various veins in the body.

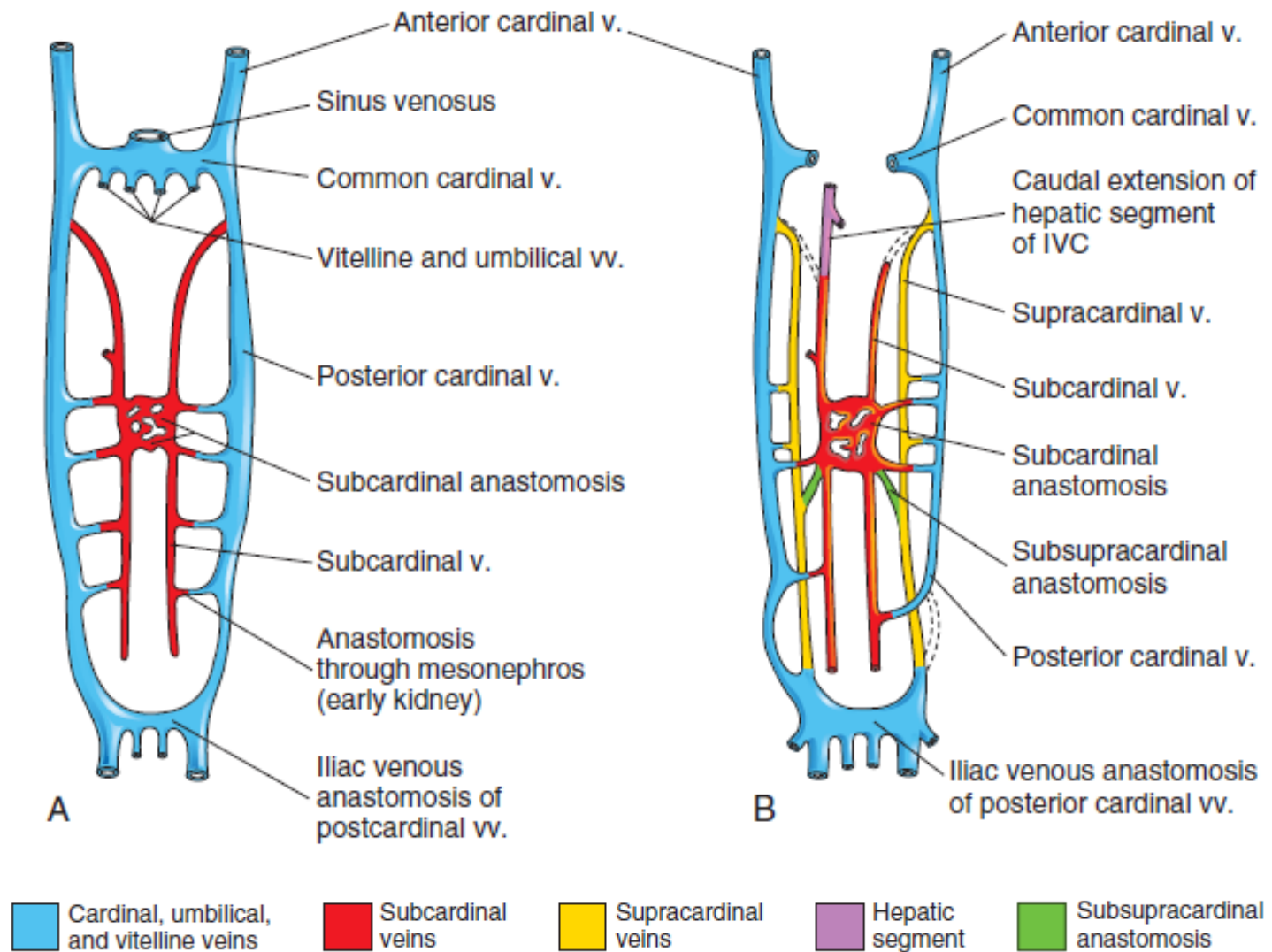


Fig.27: Development of the cardinal veins. Continued on next slide.



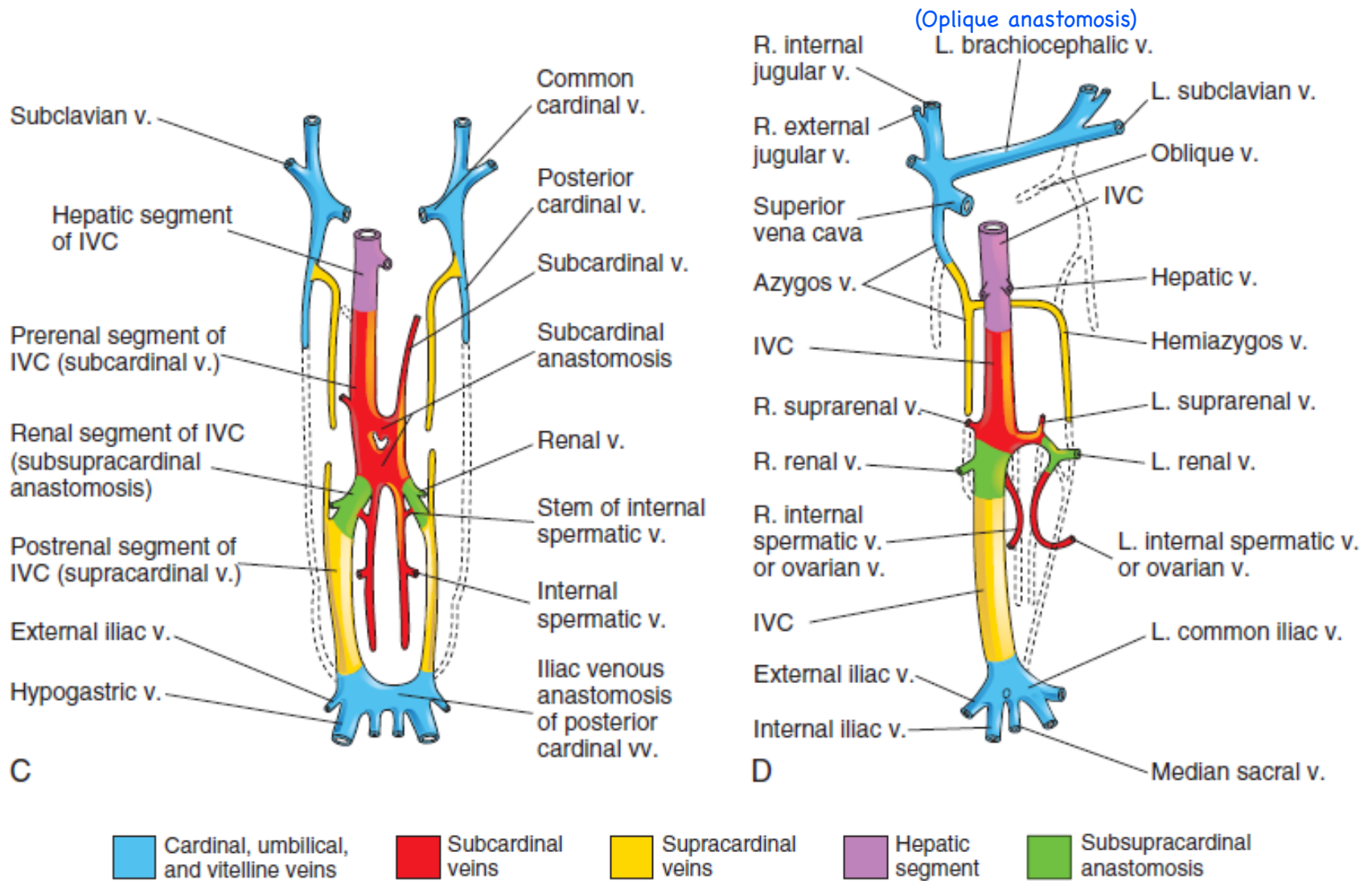


Fig.27: Continued from previous slide. Note in (D), the various parts of the inferior vena cava.

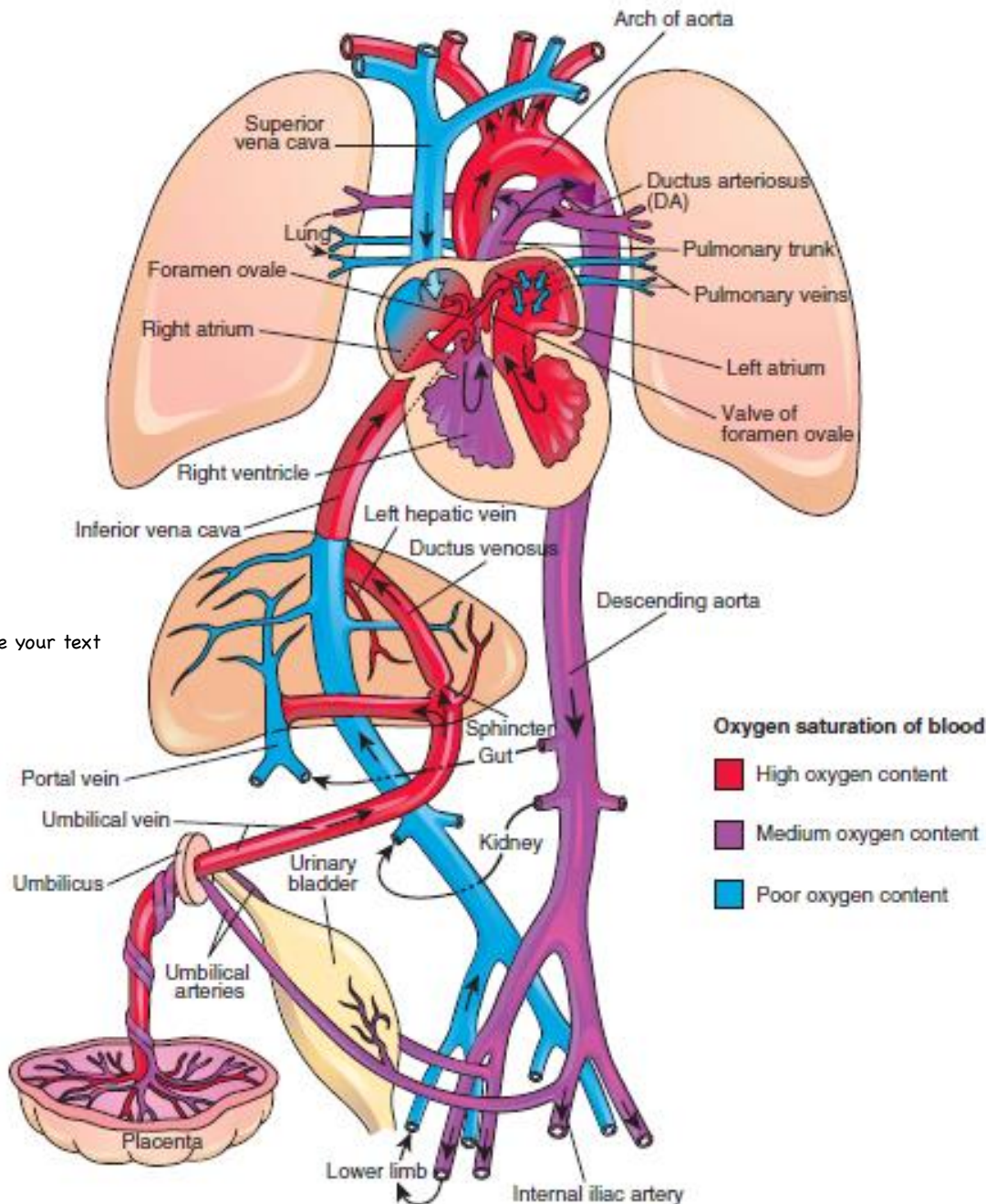


الدم الي محمل بالأوكسجين والغذاء ينتقل في الجنين من خلال placenta الي ال umbilical vein بعدين راح يوصل الي الكبد (liver)، وراح يعبر ال liver من خلال ال ductus venosus وبعدها الي ال Ivc وبعدها الي ال Rt atrium وبعدها الي ال Lt atrium من خلال ال foramen ovale، وبعدها تذهب الي ال aorta وتغذي ال upper limbs وتكمل طريقها الي ال descending aorta وتغذي ال lower limbs

# Fetal Circulation

- ❑ Highly oxygenated, nutrient-rich blood returns under high pressure from the placenta in the umbilical vein. On reaching the liver, most of the blood passes through the ductus venosus into the IVC, bypassing the liver. This is controlled by a sphincter. The rest of the blood passes into the liver sinusoids to enter the IVC through the hepatic veins. *In the liver there's a mixture with poorly-oxygenated blood coming through the portal vein.*
- ❑ After a short course in the IVC, the blood enters the RA of the heart. *In the IVC, blood is mixed with poorly oxygenated blood from the lower limbs, abdomen, and pelvis.*
- ❑ In the RA, most of the blood is directed by the valve of the IVC into the LA through the foramen ovale. *In the LA, it's mixed with small amount of poorly oxygenated blood from the lungs through the pulmonary veins.*

- ❑ This blood, still with good oxygenation, passes into the LV and then into the aorta where it supplies the head, neck, and upper limbs. After that, it reaches the descending aorta.
  
- ❑ Some of the blood in the RA, stays in the RA and is *mixed with poorly oxygenated blood coming through the SVC*. This, then, passes into the RV and the pulmonary trunk. Due to high resistance in the pulmonary vessels, most of this blood passes through the ductus arteriosus to enter the descending aorta.
  
- ❑ Medium-oxygenated blood in the descending aorta supplies the trunk and lower limbs.
  
- ❑ Blood leaves the fetus through the umbilical arteries to enter the placenta to be oxygenated.



In the fetal circulation, well oxygenated and poorly oxygenated blood are mixed in the:

- Liver
- IVC
- RA
- LA

هناك المناطق التي يمر فيها الـ oxygenated & non-oxygenated

هذا الدم غير محمل بالأكسجين (non)

-oxygenated) يأتي بطريقتين :

(1) يأتي من الـ svc (يذهب إلى كل من Ra, Rv) وبعدها يروح إلى الـ pulmonary vessels (عشان يروح للـ lung بس راح يلاقي الـ lung مسكرة فراح يرجع الدم إلى الـ Lt atrium و يروح إلى الـ aorta. (2) الـ non-oxygenated blood راح يجي برضوا من الـ lower limbs و يروح إلى الـ liver وبعدها يروح إلى الـ IVC وبعدها إلى الـ Rt atrium, وراح تكمل نفس مسار الطريقة الأولى

Fig.28: Fetal circulation.

# Changes after birth

بعد الولادة لما الدكتور يضرب ظهر الجنين راح تبلش الرئة بالعمل يعني الدم  
اللي كان يروح aorta راح يرجع لل Left atrium وراح يزداد كمية الدم فيها  
وبالتالي راح تدفش ال septum secundum نحو ال septum primum  
ويغلق ال foramen ovale وراح تتكون ال fossa ovalis، اضيفت في  
الاسلايد اللي بعده صورة خارجية كويسة عشان تفهموا النقاط

1. When the neonate takes a breath, the resistance in the pulmonary vessels decreases and more blood passes through the lung. This increases pressure in the LA. At the same time, the umbilical vein is cut reducing blood flow and pressure in the RA. This will push the septum primum against the septum secundum closing the foramen ovale. Anatomical fusion will occur later forming the fossa ovalis.
2. Hypoxia in the lungs keeps the ductus arteriosus open during fetal life. When oxygen enters the lungs after birth, the ductus will constrict and later become fibrosed to form the ligamentum arteriosum.
3. The umbilical vein becomes the ligamentum teres and the ductus venosus becomes the ligamentum venosum.
4. The distal parts of the umbilical arteries form the medial umbilical ligaments with the proximal parts forming the superior vesical arteries.

