
The university of Jordan
Faculty of medicine



CVS Embryology 2

Dr Ahmed Salman

Associate professor of Anatomy and embryology

BULBUS CORDIS

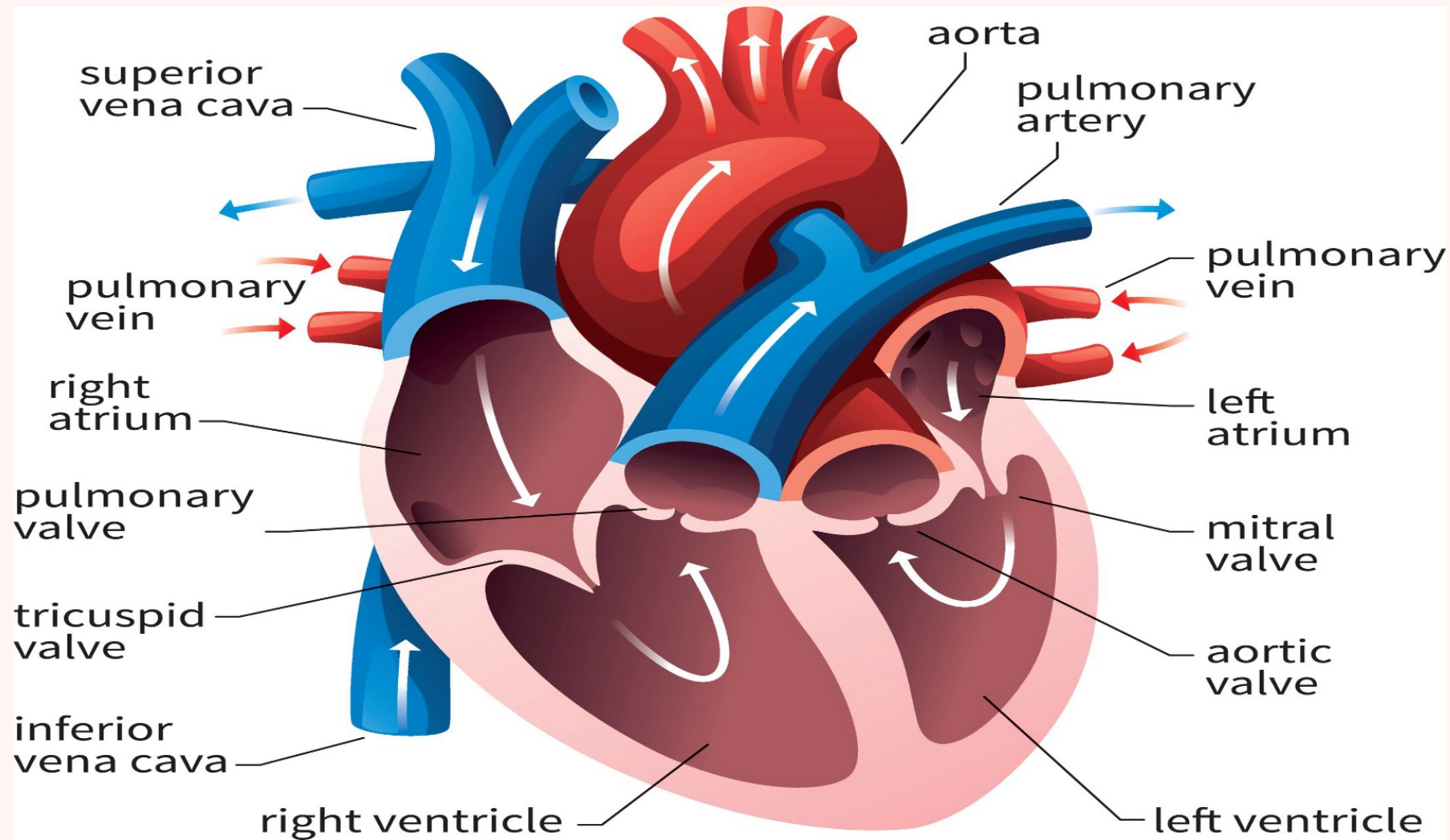
I) Parts of the bulbs cordis:

1- The proximal-portion part (conus cordis): is absorbed into the ventricles forming the outflow tracts of the both ventricles.

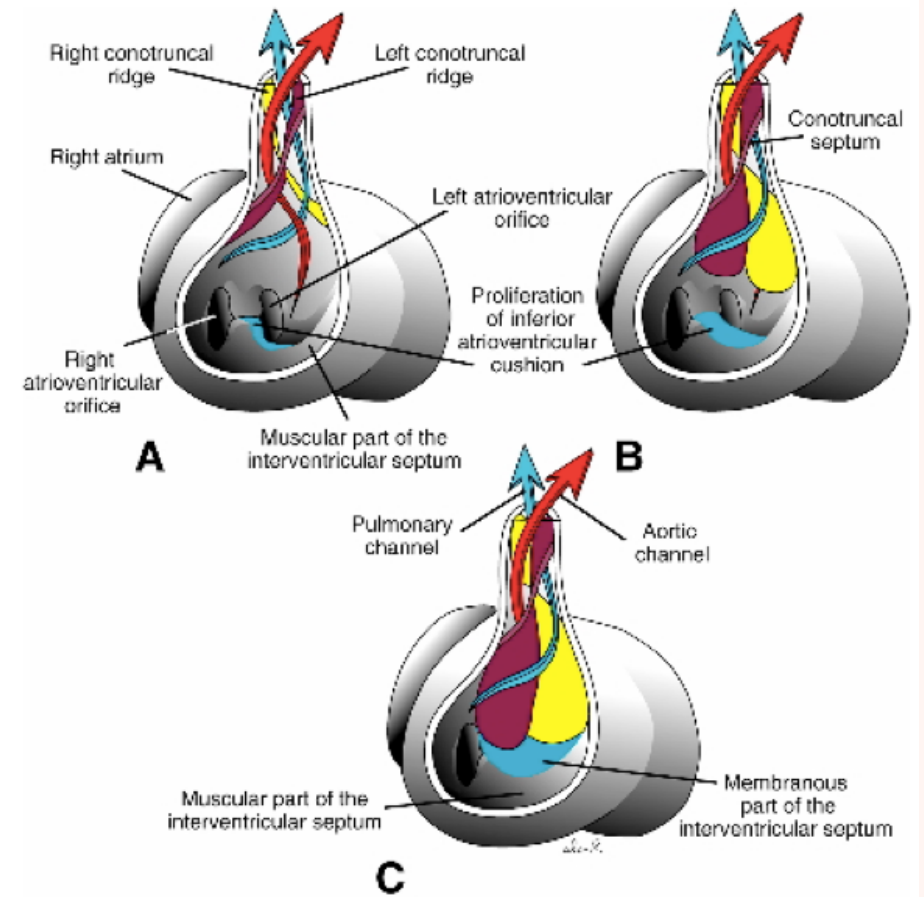
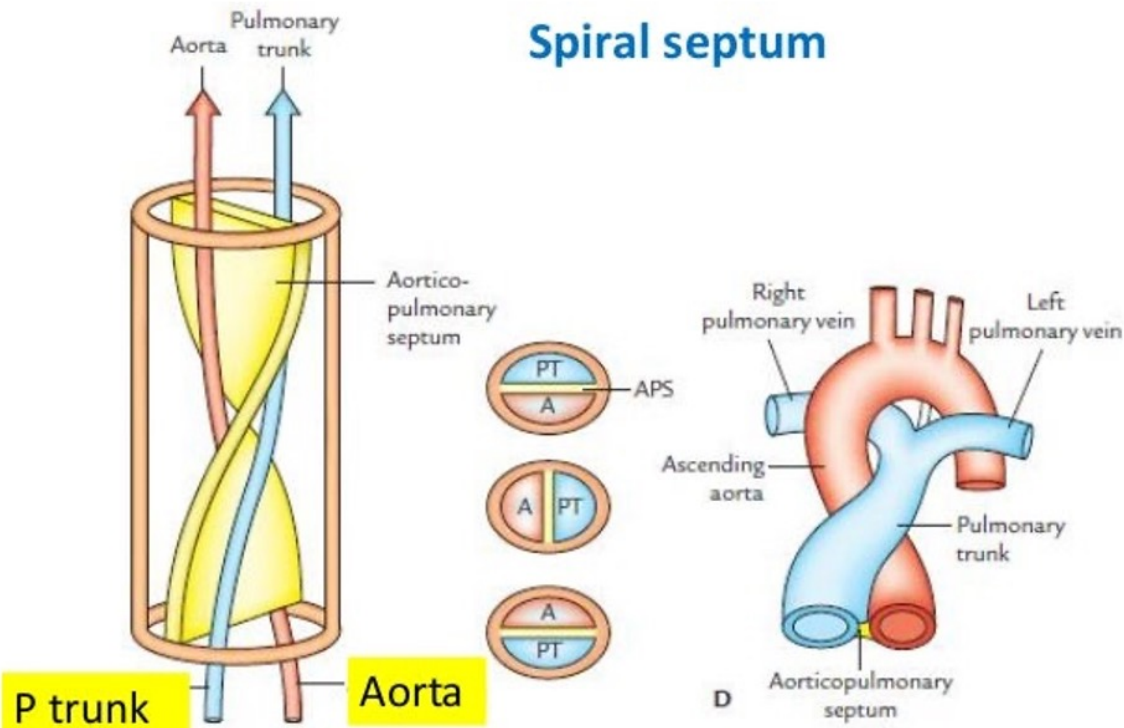
3-The distal part (truncus arteriosus): is divided by the spiral **aortico-pulmonary septum** into roots and proximal portions of the ascending aorta and pulmonary trunk.

II) Formation of the aortico-pulmonary septum:

1. During the 5th week, 2 truncal ridges in the truncus arteriosus (right and left) are developed.
 2. These ridges grow forming 2 longitudinal ridges .
 3. By the 8th week, the 2 ridges become fused to form a spiral aortico-pulmonary septum dividing the truncus arteriosus into pulmonary trunk and ascending aorta.
 5. The spiral course of the aortico-pulmonary septum explains:
 - ❖ Adult relations between the ascending aorta and pulmonary trunk; the pulmonary trunk lies anterior then to the left and finally posterior to the aorta
 - ❖ The 2 arteries are enclosed in a common tube of visceral pericardium
-



Spiral septum



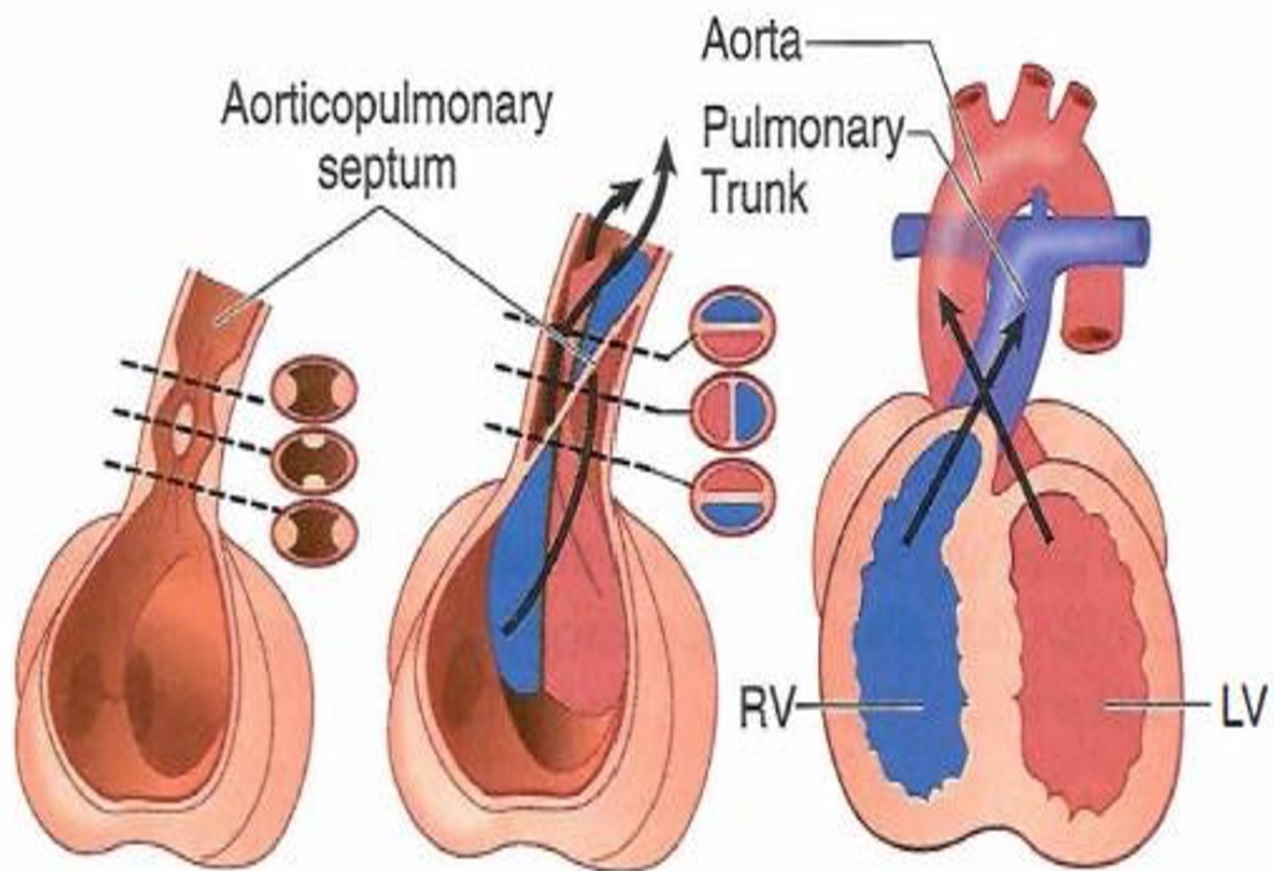


Figure III-2-18. Formation of the Aorticopulmonary Septum

ANOMALIES OF BULBUS CORDIS

1- Fallot's tetralogy

It is common **cyanotic** congenital heart disease

The aortico-pulmonary septum is shifted anteriorly leads to unequal division of the conus.

This is cause right to left shunt of the blood

Characters:

1-Pulmonary stenosis

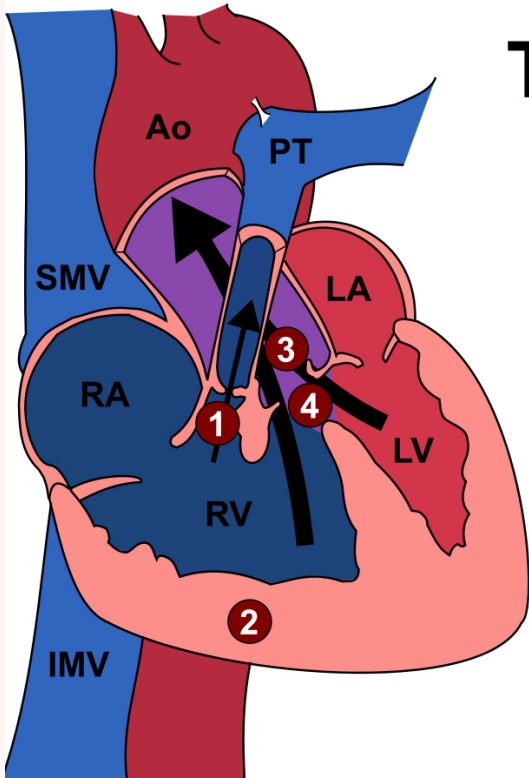
2-Overriding aorta i.e. the mouth of aorta receives blood from both Right and left ventricles.

3-Ventricular septal defect

4-Hypertrophy of Right ventricle

X ray show boot shaped heart due to right ventricle enlargement

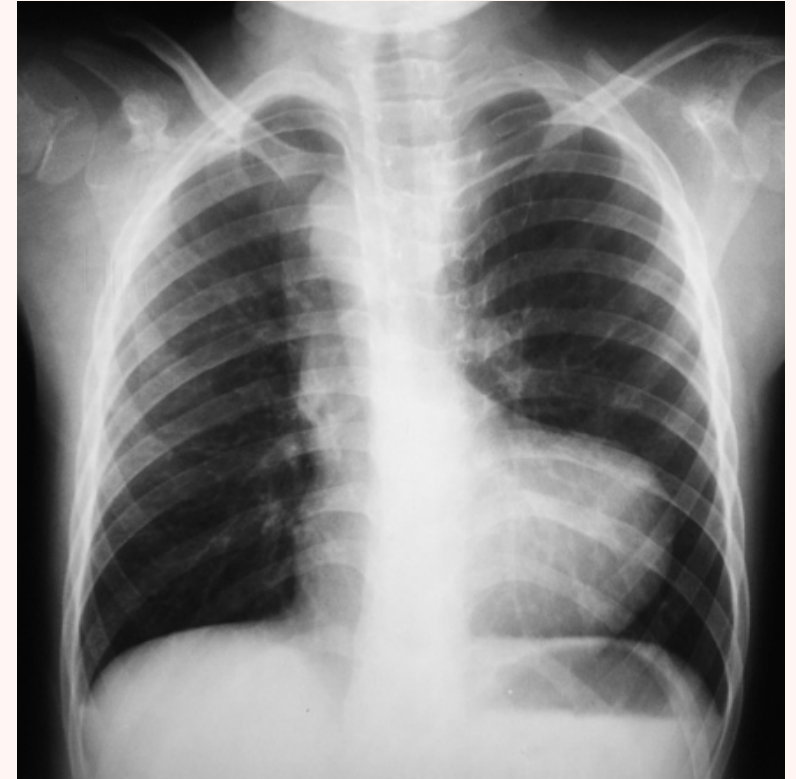
Tetralogy of Fallot



Major Defects

- 1 Pulmonary Stenosis
- 2 Right Ventricular Hypertrophy
- 3 Overriding Aorta
- 4 Ventricular Septal Defect

Lineage ©
Moises Dominguez

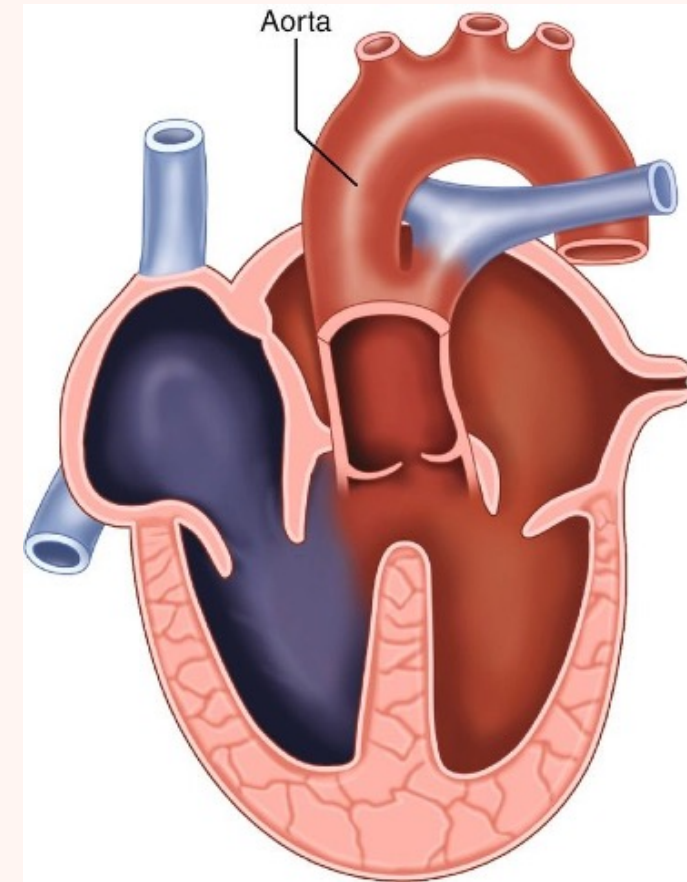


Boot shaped heart

2- Persistent truncus arteriosus :

Cause: failure of formation of the aortico-pulmonary septum.

It is accompanied by: membranous ventricular septal defect.

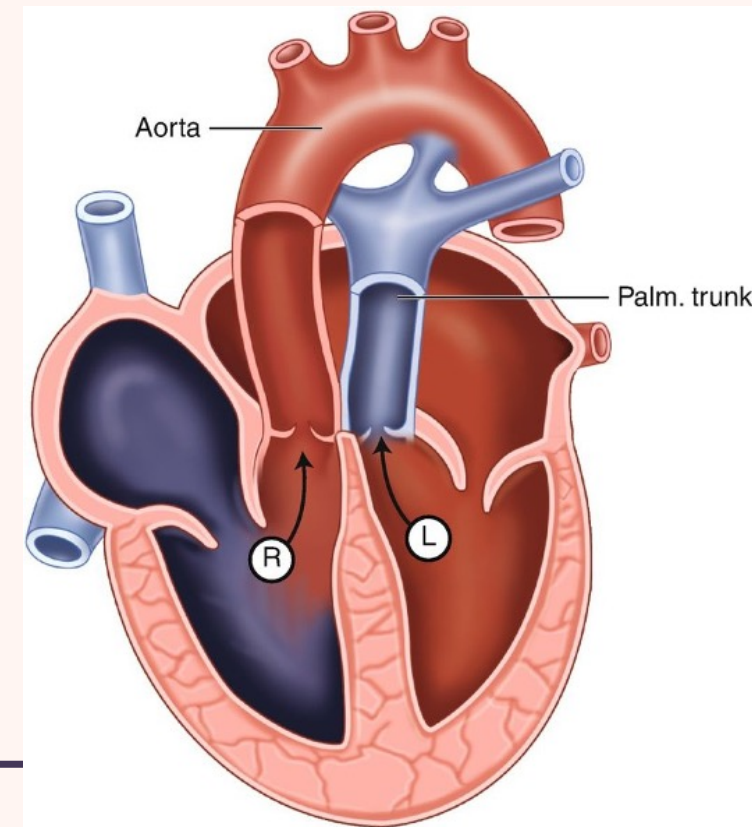


3- Transposition of the Greater Arteries :

Cause: the aortico-pulmonary septum runs a straight course instead of its spiral course.

It leads to:

- ❖ Aorta arising from the right ventricle.
 - ❖ Pulmonary trunk arising from from the left ventricle
 - This cause right to left shunt of the blood (**Cyanotic**)
 - This is cause sever cyanosis and death after birth
 - Usually it is accompanied by other defects as ASD ,VSD ,PDA
- Which cause mixing oxygenated and NON oxygenated blood to sustain life



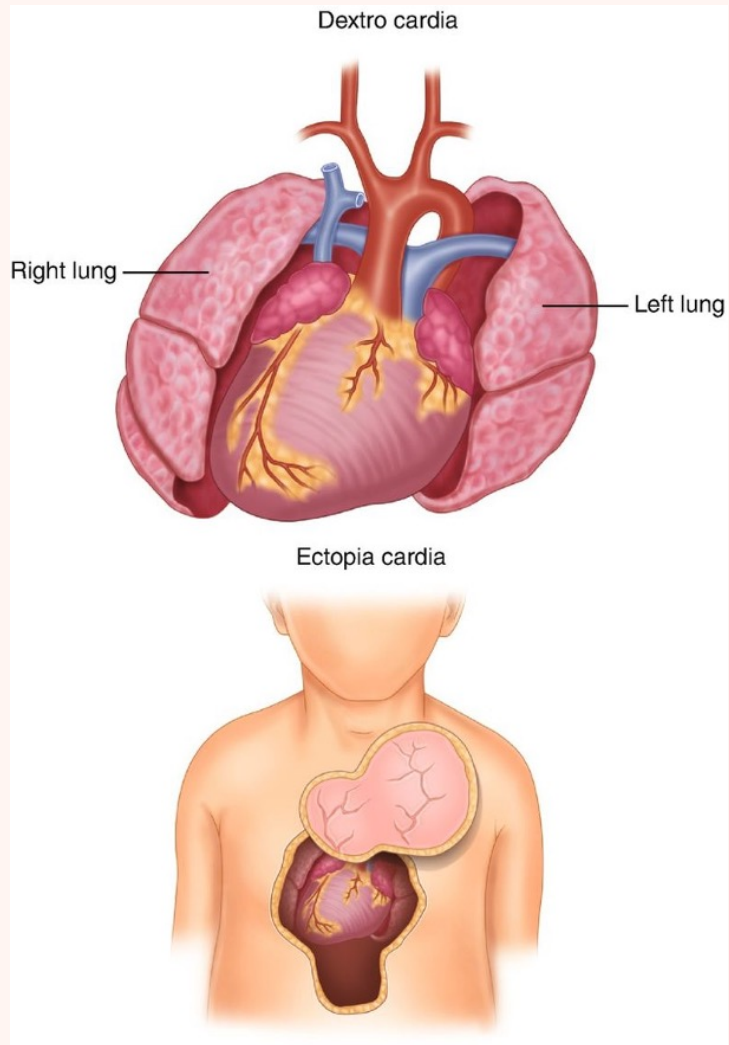
ANOMALIES OF POSITION OF THE HEART

1- Dextrocardia :

- The heart and its great vessels lie as a mirror image to their normal position.
- This may occur alone or may be associated with reversal of all abdominal organs (**situs inversus totalis**).

2- Ectopia cordis:

- The heart is exposed to the surface of the thorax through a defect in the sternum.
 - It is due to failure of the embryo to close in the middle line.
-



Development of Great Arteries

READ ONLY

The great vessels start to develop in the middle of week **3** , simultaneously with formation of cardiac field , from primitive **angiogenic mesodermal** cells which form blood islands .

Development of the aorta and aortic sac :

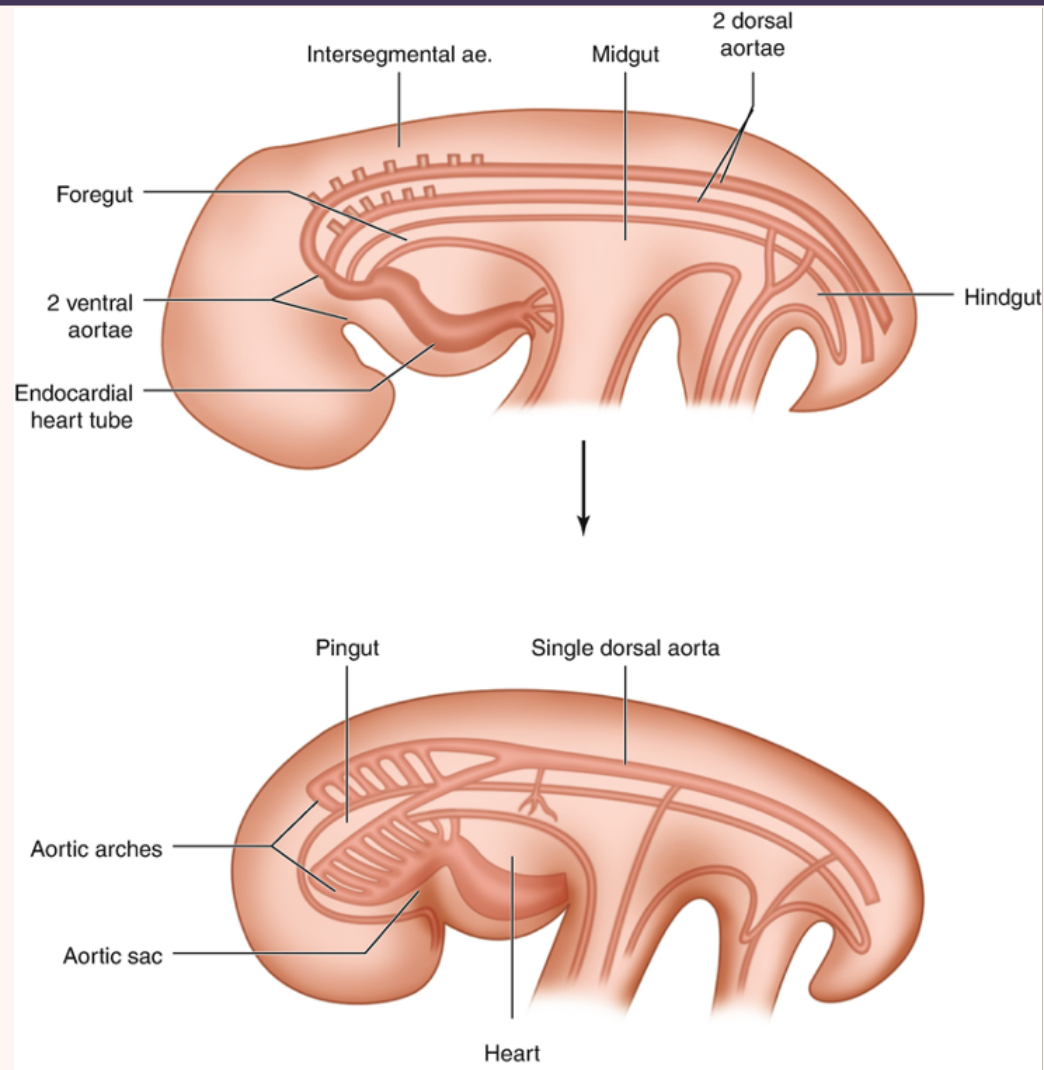
I) Right and left primitive aorta and the 2 dorsal aorta :

1. Blood islands unite to form the first intra-embryonic arteries which are the right and left primitive aorta, which are developed simultaneously and continuous with the 2 endocardial tubes .
 2. They lie ventral to the foregut (**2 ventral aorta**).
 3. From this site they curve dorsally and continue caudally and dorsal to the gut as **2 dorsal aorta**.
-

READ ONLY

II) Aortic sac and the common dorsal aorta :

1. As the 2 endocardial tubes fuse with each other to form the single endocardial tube , the 2 ventral aorta also fuse to form the **aortic sac** which is continuous caudally with the truncus arteriosus and dorsally with the 2 dorsal aorta .
 2. As the pharyngeal arches begin to develop, the aortic sac sends a branch to each pharyngeal arch , giving rise to 6 pairs of arteries (**the aortic arches**). The aortic arches curve dorsally through the corresponding pharyngeal arches to join the 2 dorsal aorta.
 3. Caudally, beyond the level of the 6th aortic arches the **2 dorsal aortae** approach each other and finally fuse forming **a single dorsal aorta**.
-



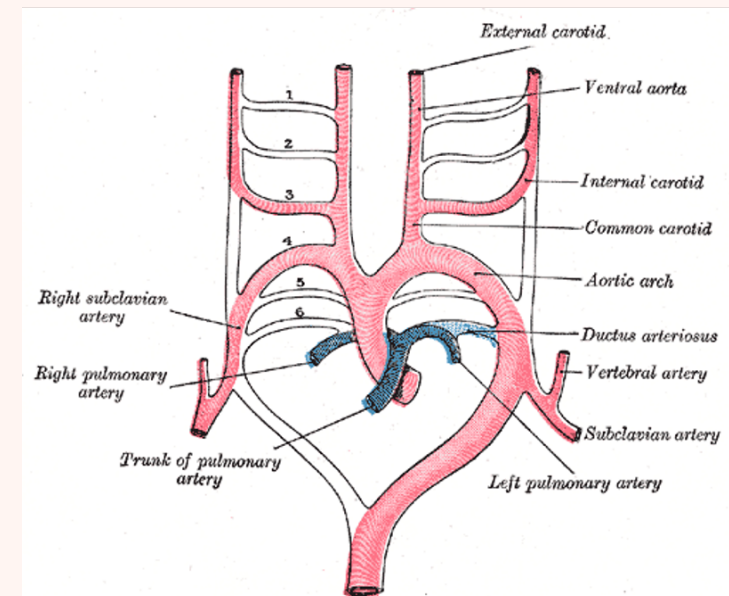
* The vessels of the embryo is developed from 3 sources :

- 1- **Aortic sac .**
- 2- **Aortic arches .**
- 3- **Dorsal & common aorta.**

Fate of aortic sac

The aortic sac has two horns (right and left)

- The **right horn** forms the **brachiocephalic artery**.
- The **left horn** form the **proximal part of the arch** of aorta.

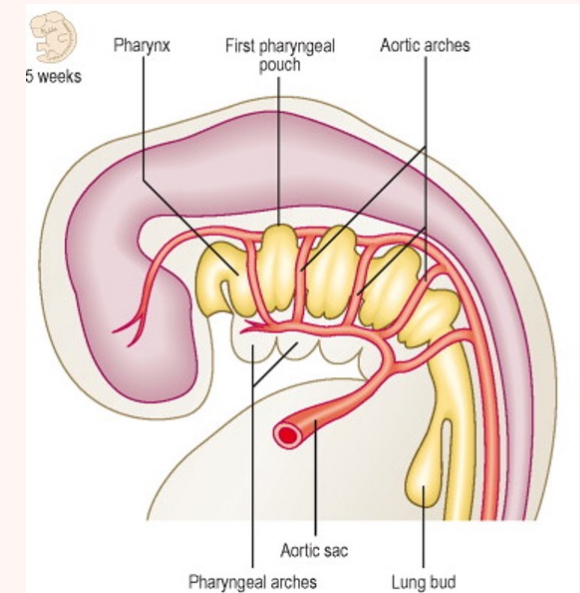


AORTIC ARCHES

They are 6 pairs of arteries, which connect the aortic sac ventrally with the 2 dorsal aorta dorsally.

Formation:

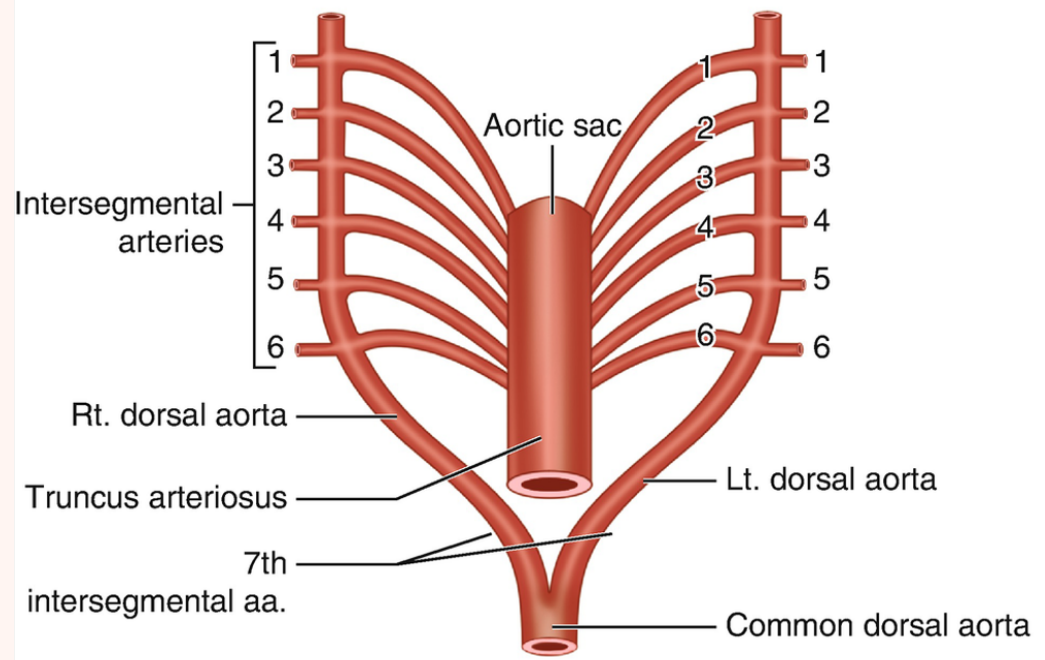
- 1.As the pharyngeal arches begin to develop, the aortic sac sends a branch to each pharyngeal arch, giving rise to 6 pairs of arteries.
- 2.Each branch leaves the aortic sac, curves around inside the corresponding pharyngeal arch to end in the dorsal aorta.



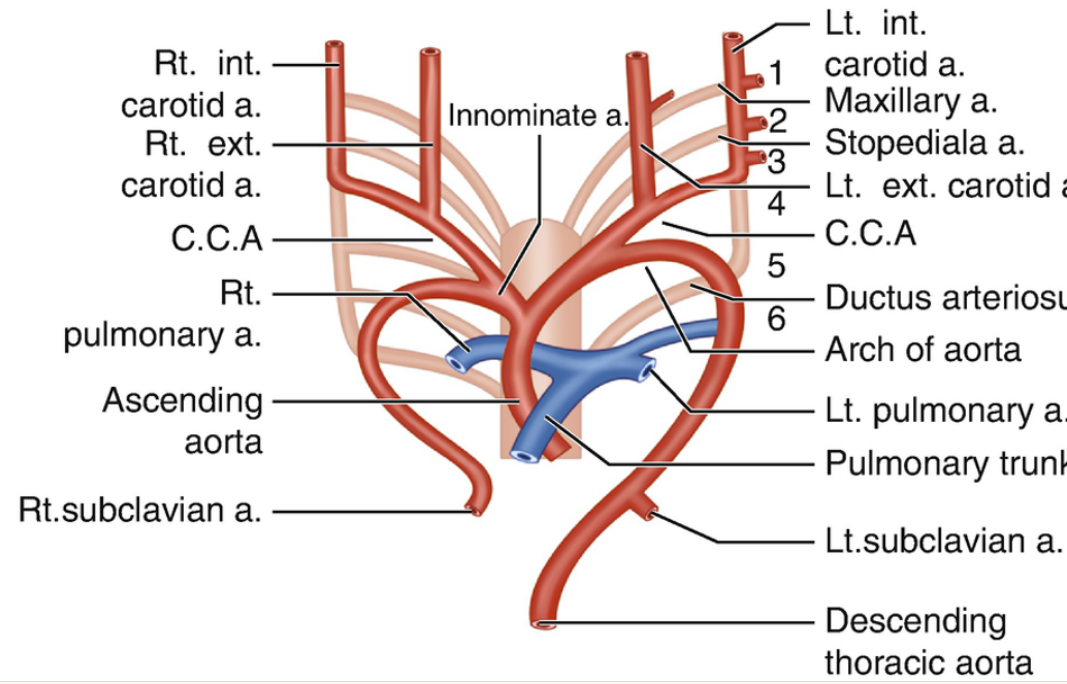
Fate of the aortic arches :The aortic arches undergo the following changes:

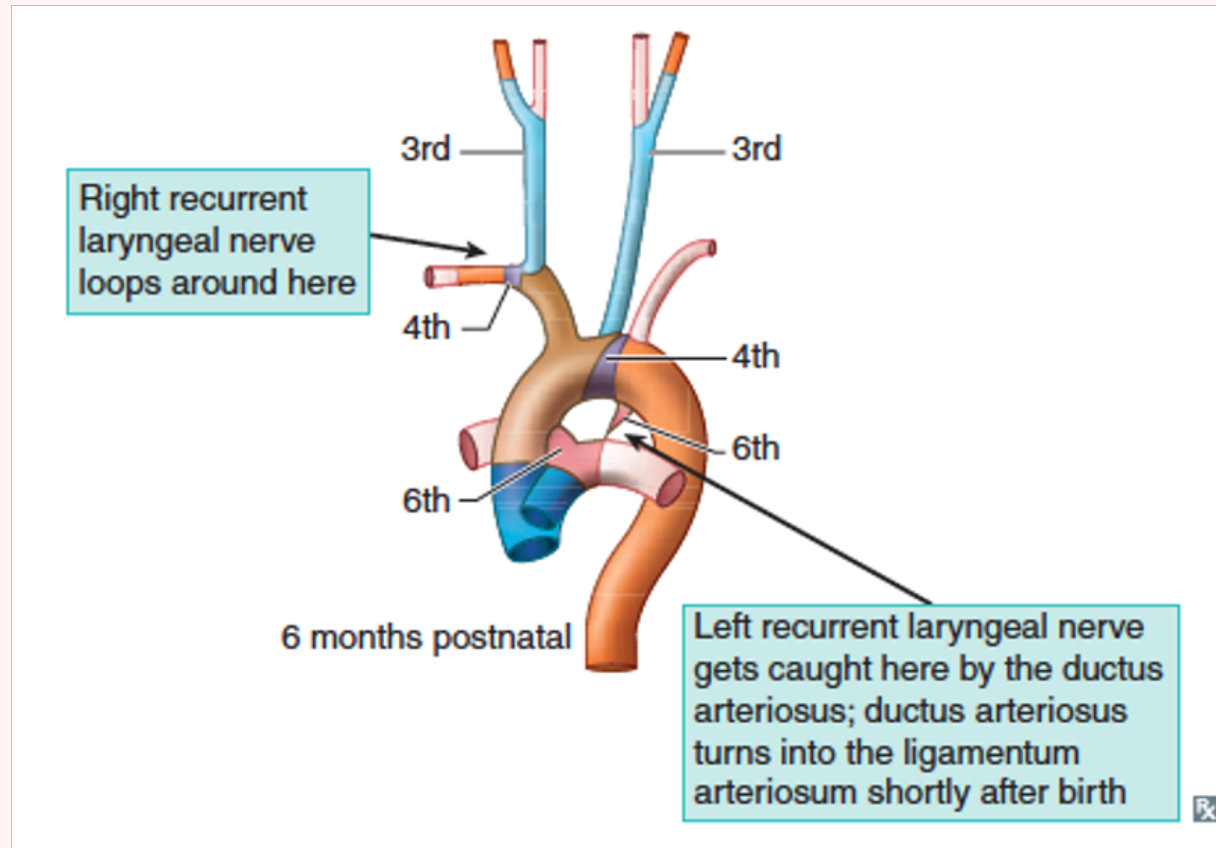
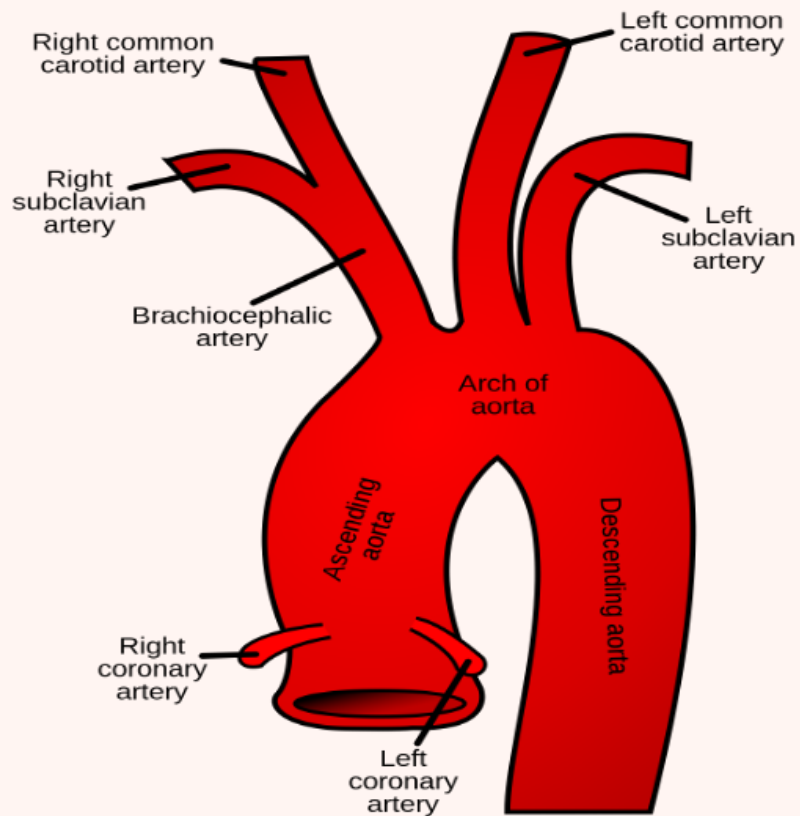
Aortic arch	Right	Left
1st	Disappears except for a small part which forms the Maxillary artery .	
2nd	Forms the hyoid and Stapedial artery .	
3rd	Forms the Common Carotid Artery and proximal part of the Internal Carotid Artery External carotid is developed from a bud from CCA	
4th	Forms the proximal part of the right subclavian artery .	Forms the middle part of the arch of aorta .
5th	Disappears completely	
6th Ventral	Forms the right pulmonary artery .	Forms the left pulmonary artery .
6th Dorsal	Disappears.	Persists forming the ductus arteriosus which forms a connection between the left pulmonary artery and arch of aorta.

Formation of the aortic arches



Fate of the aortic arches





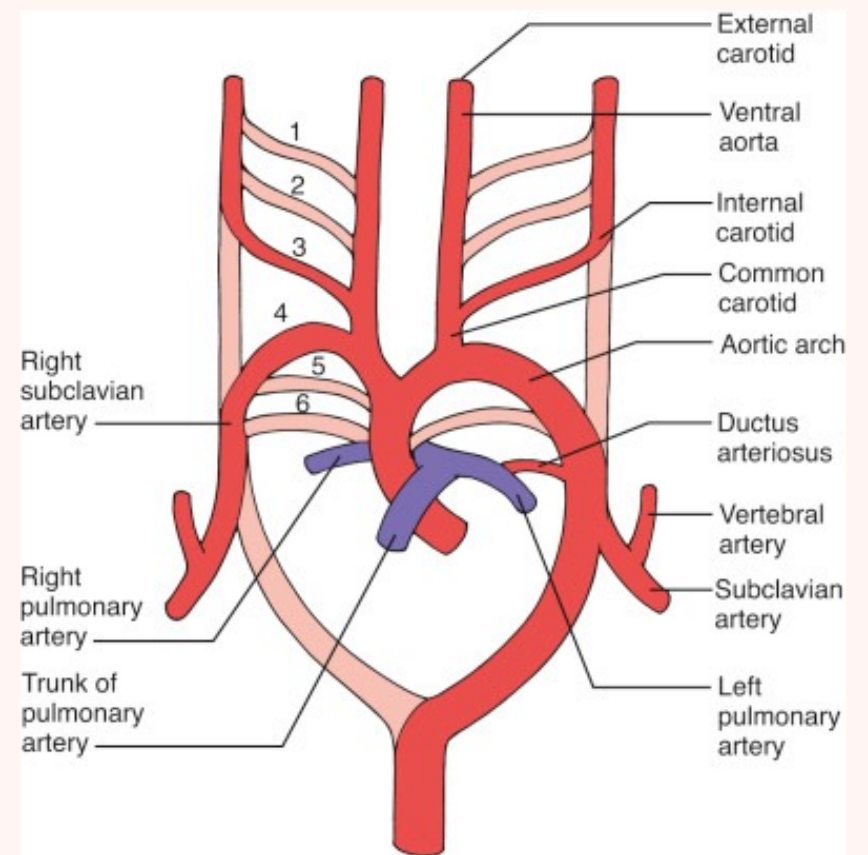
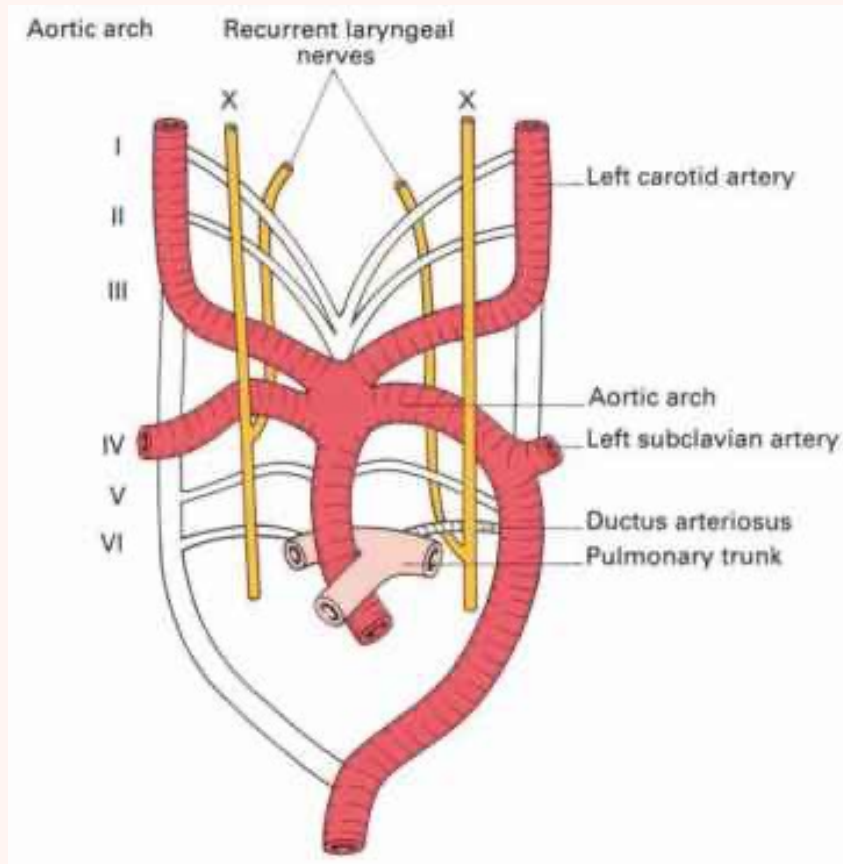
Development of the arch of aorta

* The arch of aorta is developed from:

- **Its proximal part:** arises from the left horn of aortic sac .
- **Its middle part:** arises from the left 4th aortic arch.
- **Its distal part:** arises from the lower part of the left dorsal aorta to the level of 7th inter-segmental artery.

* **N.B.: The difference of the course of the right and left recurrent laryngeal nerves:**

- Initially, these nerves, supply the sixth pharyngeal arches. When the heart descends, they hook around the sixth aortic arches and ascend again to the larynx.
 - On the right, the dorsal part of the 6th aortic arch and the 5th aortic arch disappear, the recurrent laryngeal nerve hooks around the right subclavian artery which develops from 4th. aortic arch .
 - On the left the nerve does not move up, since the dorsal part of the sixth aortic arch persists as the ductus arteriosus, which later forms the ligamentum arteriosus.
-



DORSAL AORTA

Fate of dorsal aorta:

The segment	Right	Left
Cranial to the 3rd aortic arch:	Forms the distal part of the I.C.A.	
Between the 3 rd and 4 th aortic arch (Ductus caroticus):	Disappears.	
Between the 4th aortic arch and 7th inter-segmental artery:	Forms part of the right subclavian artery.	Forms the distal part of the arch of the aorta
Caudal to the 7th inter-segmental artery and common dorsal aortae:	Disappears.	Forms descending aorta

Branches of dorsal aorta:

I) Branches from 2 dorsal aorta : In the cervical region

- ☑ There are **seven cervical intersegmental** arteries arising from each of the right and left dorsal aorta.
- ☑ The **upper six** become connected by **vertical anastomoses** which will give rise to **2nd part of vertebral artery** (and the **deep cervical arteries** as well as the **superior intercostal artery**).

N.B Know 2nd part of vertebral A. only

- ☑ **7th intersegmental artery forms:**
 - The lower part of the **right subclavian** artery on the right side.
 - The whole **left subclavian** artery on the left side.
-

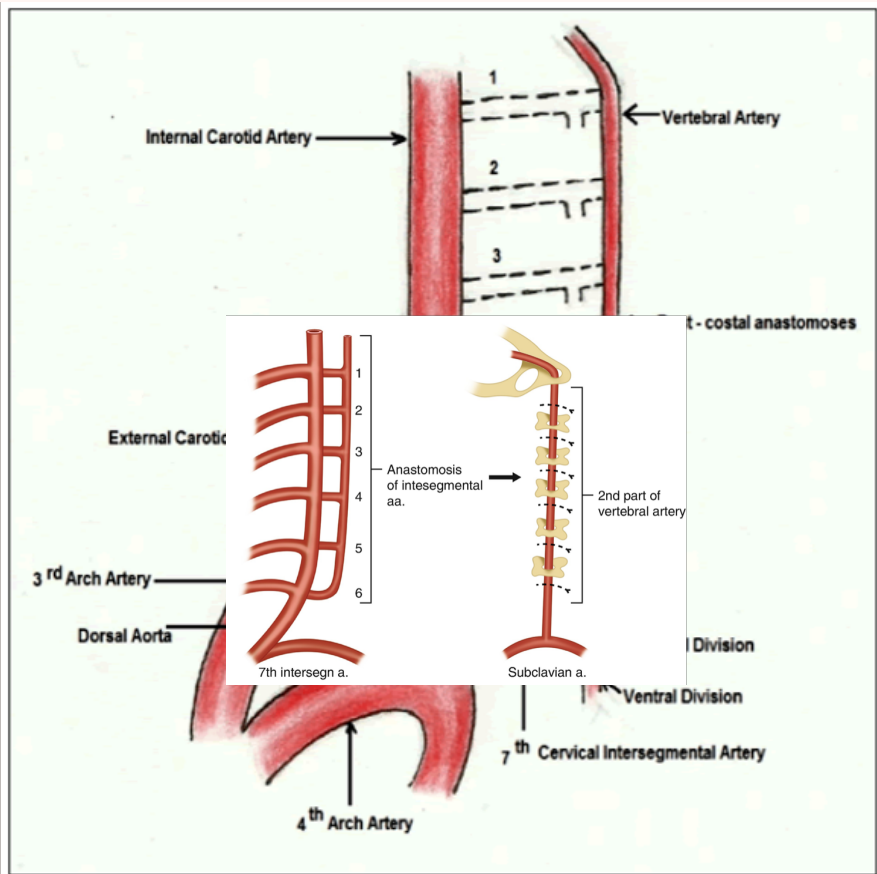
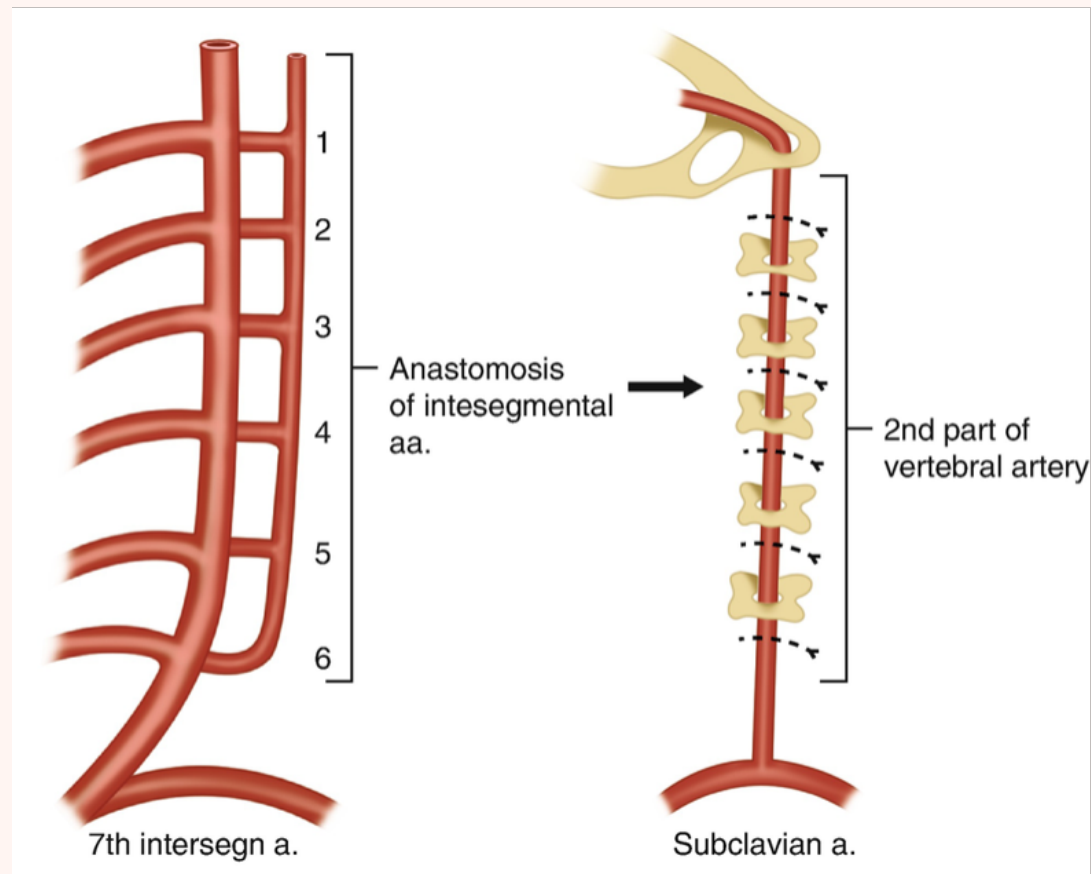


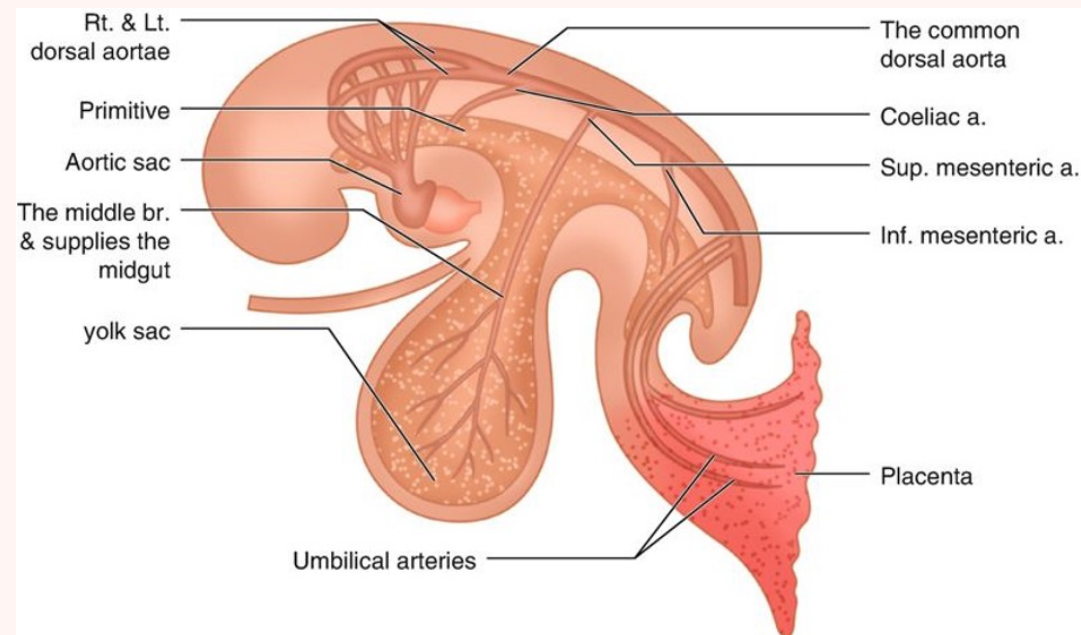
Figure 3. Diagrammatic representation of the development of the vertebral artery.



I) Branches from common dorsal aorta :

1-Ventral splanchnic_arteries :

- a. Coeliac artery: the most cranial and supplies the foregut.
- b. Superior mesenteric artery: the middle and supplies the midgut.
- c. Inferior mesenteric artery : the most caudal and supplies the hindgut.



2- Lateral splanchnic arteries :

- a. Inferior phrenic arteries.
- b. Middle suprarenal arteries.
- c. Renal arteries.
- d. Gonadal arteries.

3- Somatic (intersegmental) arteries : (THIS PARAGRAPH IS READ ONLY)

- The **intersegmental vessels** come from the posterolateral aspect of the dorsal aorta and pass laterally between the **somites** to supply the structures derived from somites (e.g. bone, muscle).
 - They run in the cervical, thoracic, lumbar and sacral regions.
 - There are 7 cervical , 12 thoracic and 5 lumbar and 4 sacral intersegmental arteries .

They anastomose both ventrally and dorsally, and their **ventral anastomoses** produce the internal thoracic, superior epigastric and inferior epigastric arteries in the adult

Fate of the intersegmental arteries :

In the thorax: persist as 11 posterior intercostals and subcostal arteries.

In the abdomen: persist as 4 lumbar arteries, while the 5th lumbar becomes common iliac artery .

In the sacral region: persist as lateral sacral arteries.

4- Terminal (umbilical) arteries :

The 2 umbilical arteries are initially paired ventral branches of the common dorsal aorta.

Each artery anastomoses with the 5th lumbar intersegmental artery .

5th lumbar intersegmental artery gives a branch i.e. **External iliac artery**

The proximal part of umbilical artery continues as **internal iliac artery** .

After birth, the distal part of umbilical artery is obliterated to form the medial umbilical ligaments.

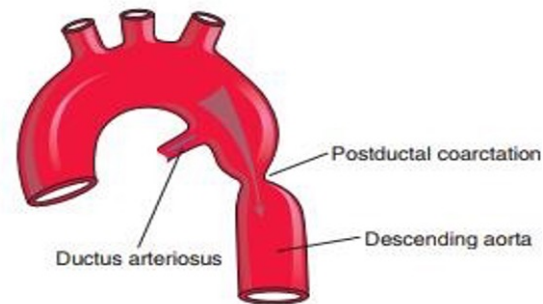
Congenital Anomalies of Arteries

1) Coarctation of the aorta :

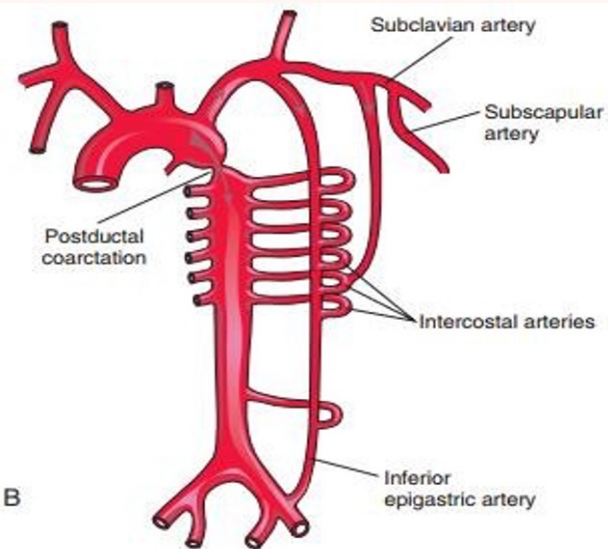
- Is narrowing of the aorta distal to the origin of left subclavian artery . There are 2 types:
 - 1. Pre-ductal type:** if the narrowing is proximal to the ductus arteriosus.
 - 2. Post-ductal type:** if the narrowing is distal to the ductus arteriosus.
- Clinically, absent or diminished pulses in the femoral arteries of both lower limbs is a sign of aortic coarctation
- To compensate for the diminished volume of blood reaching the lower part of the body, a collateral circulation develops, with dilatation of the internal thoracic, subclavian, and posterior intercostal arteries.
- The dilated intercostal arteries erode the lower borders of the ribs, producing characteristic notching, which is seen on radiographic examination

2) Patent ductus arteriosus :

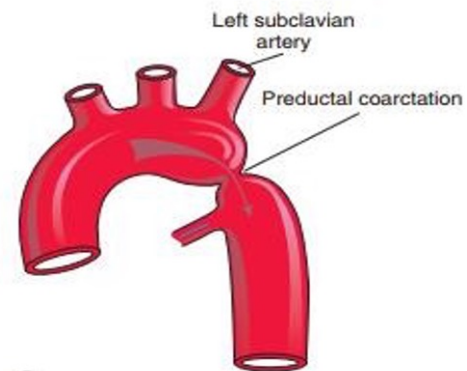
- Normally the ductus arteriosus is closed by contraction of its muscular wall shortly after birth and within 1-3 months fibrosis of the duct is complete.
 - Failure of this closure results in shunt between arch of aorta and left pulmonary artery.
-



A



B

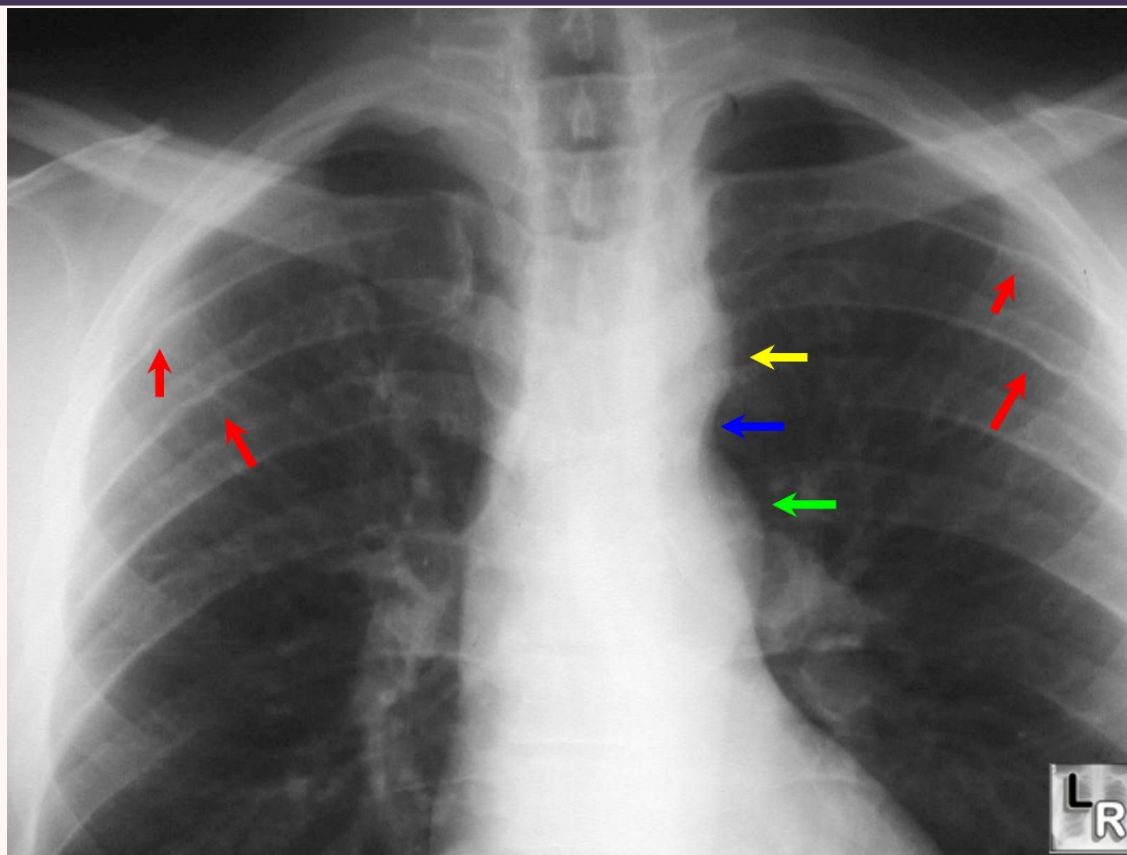


C



D

Figure 14-28 A, Postductal coarctation of the aorta. B, Common routes of the collateral circulation that develop in association with postductal coarctation of the aorta. C, Preductal coarctation. Arrows indicate flow of blood. D, Preductal coarctation (arrow) in the aorta in an adult.



Close up of upper thorax in a patient with Coarctation of the Aorta. The red arrows point to rib notching caused by the dilated intercostal arteries. The yellow arrow points to the aortic knob, the blue arrow to the actual coarctation and the green arrow to the post-stenotic dilation of the descending aorta

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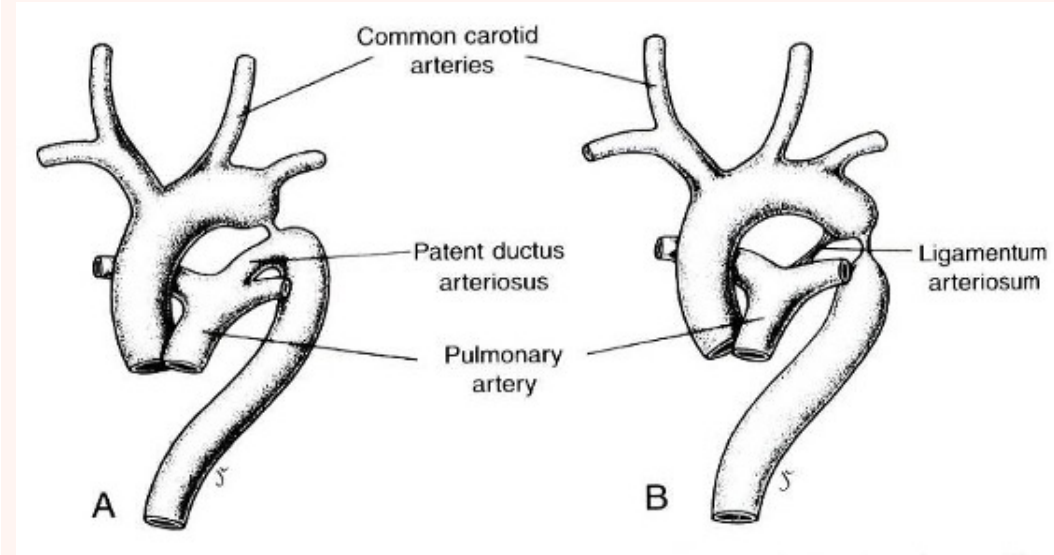
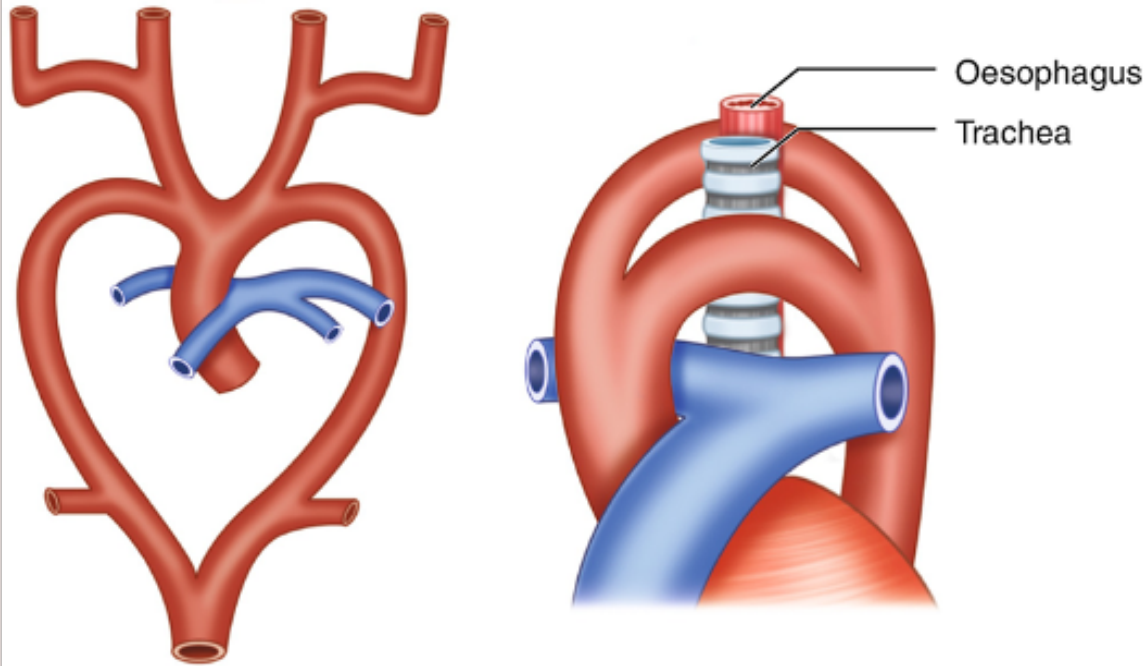
3) Abnormal origin of right subclavian artery: The right subclavian is formed from the left 7th intersegmental artery and the distal segment of the left dorsal aorta.

4) An interrupted aortic arch :

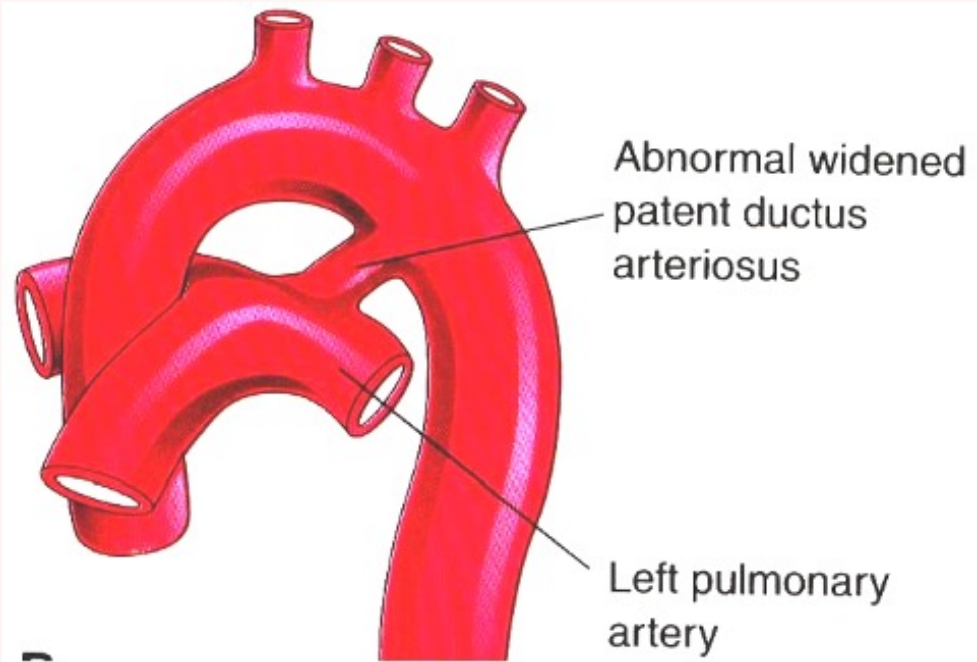
- It is caused by obliteration of the 4th aortic arch on the left side.
- The aorta supplies the head; the pulmonary trunk by the way of the ductus arteriosus supplies the rest of the body.

5) Right sided aortic arch: Results from persistence of the distal part of right dorsal aorta and degeneration of the distal part of left dorsal aorta.

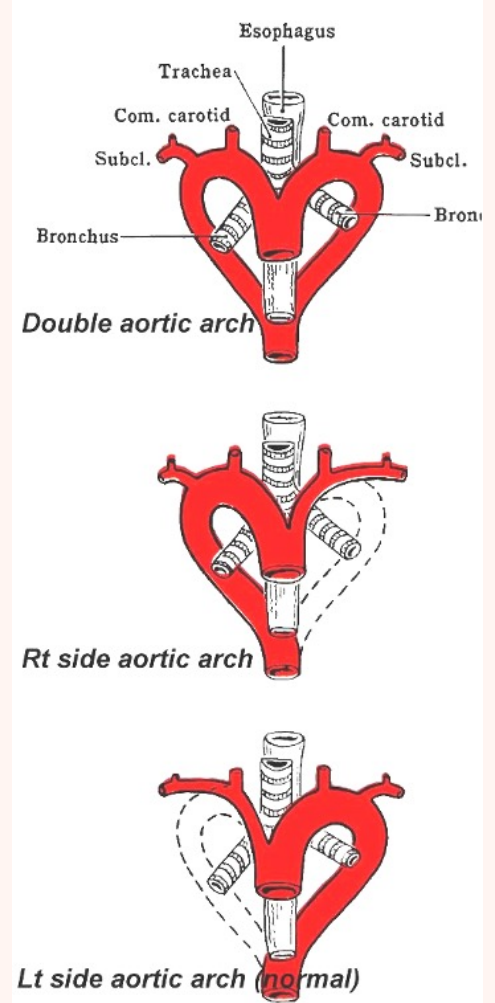
6) Double aortic arch: results from persistence of distal parts of right & left dorsal aortae



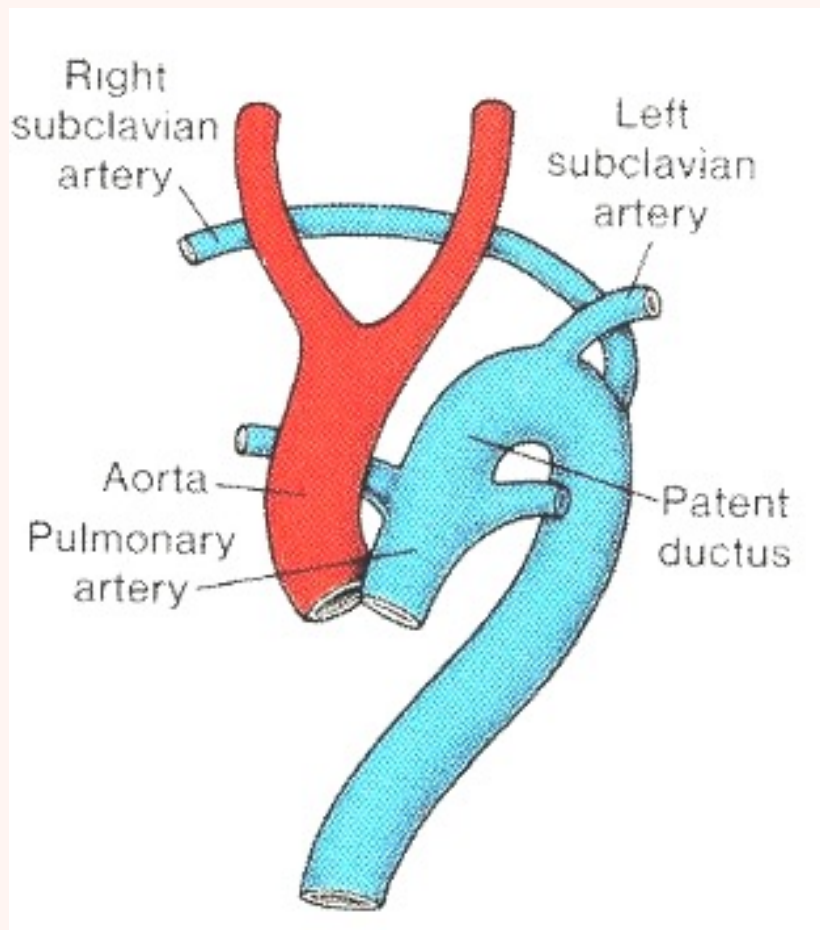
Coarctation of aorta
(A=preductal, B= postductal)



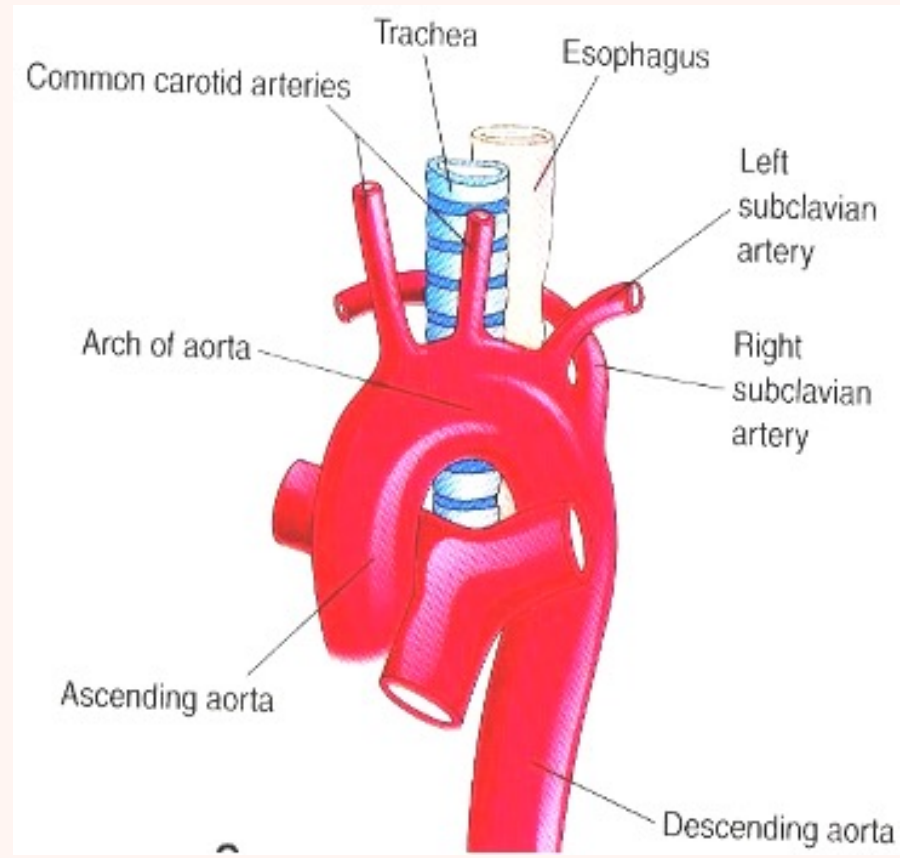
PDA



Rt side aortic arch & Double aortic arch



Interrupted aortic arch

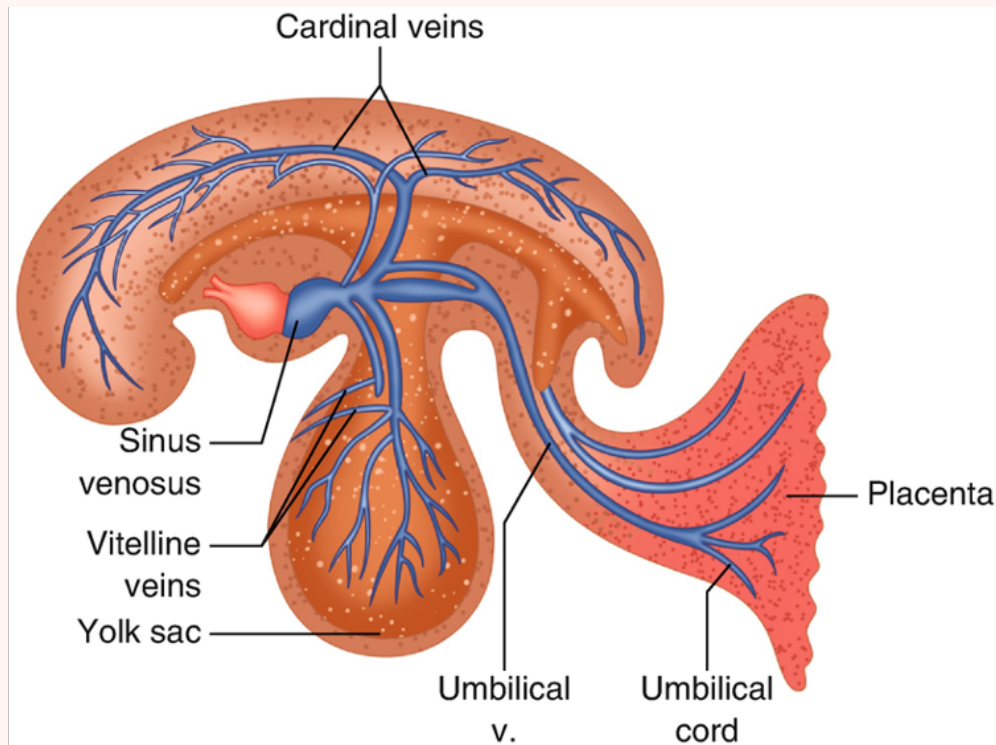


Anomalous origin of Rt subclavian

DEVELOPMENT OF VEINS

There are 3 groups of veins:

- 1) **2 Vitelline veins:** drain the yolk sac & gut .
- 2) **2 Umbilical veins:** carry oxygenated blood from the placenta.
- 3) **Cardinal veins:** drain the body of the embryo itself



VITELLINE VEINS

- These are 2 veins which arise in the mesoderm in the wall of the yolk sac.
- They traverse the septum transversum to end in the **corresponding horn of the sinus venosus**.

Fate :

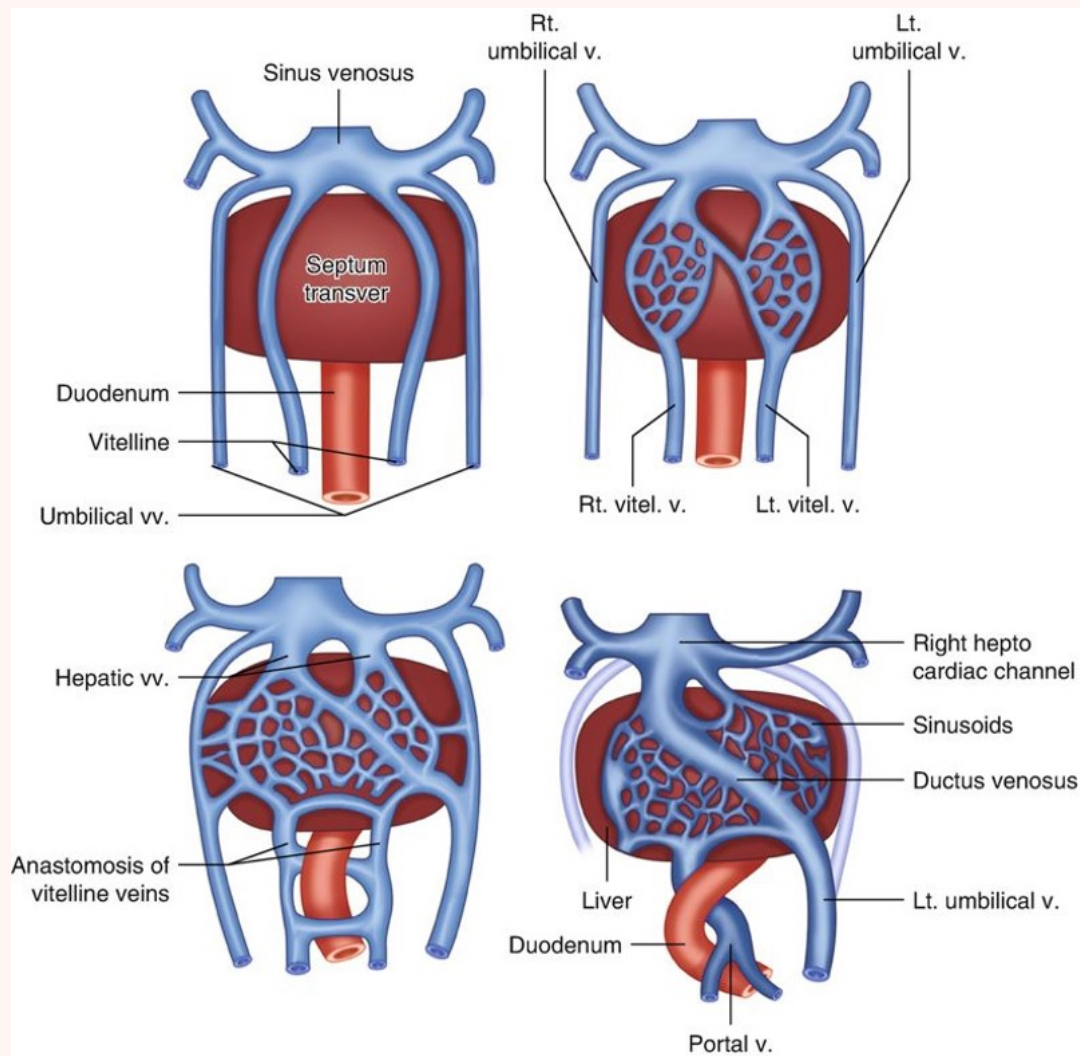
Caudal to the septum transversum:

- The 2 veins are connected together by 3 anastomoses (2 ventral and one dorsal).
- Partial degeneration of these 3 anastomoses leads to formation of (splenic & superior mesenteric veins).

In the septum transversum: The 2 veins are broken by the proliferating hepatic cords into **hepatic sinusoids**.

Cranial to the septum transversum:

- The left vitelline vein disappears completely.
 - The right vitelline vein forms the terminal part of the **IVC**.
-



UMBILICAL VEINS

These are 2 veins which pass in the umbilical cord and in the septum transversum to end in **corresponding horn of the sinus venosus.**

Fate :

- The right vein disappears completely.
- **The left vein undergoes the following changes:**

Cranial to septum transversum **disappears.**

Within the septum transversum is transformed into:

- Hepatic **sinusoids** by the invading liver cords.
- A large venous channel (**ductus venosus**) develops within the liver connecting the left umbilical vein with the IVC.

Caudal to the septum transversum becomes **left umbilical vein**

Cardinal Veins

- These are longitudinal veins which lie in the body wall of the embryo.
- They will give rise to the **main systemic veins** of the adult.

The cardinal veins include the following:

1. Anterior cardinal veins.
 2. Posterior cardinal veins.
 3. Common cardinal veins.
 4. Supracardinal veins drains upper part of the body
 5. Subcardinal veins drains kidneys
 6. Sacrocardinal veins drains lower extremities
-

Anterior cardinal veins

They lie one on each side and drain the **cephalic part of the embryo** i.e. head and neck as well as the upper limbs.

- The 2 anterior cardinal veins are **connected** together by a transverse anastomosis.

* **Fate :**

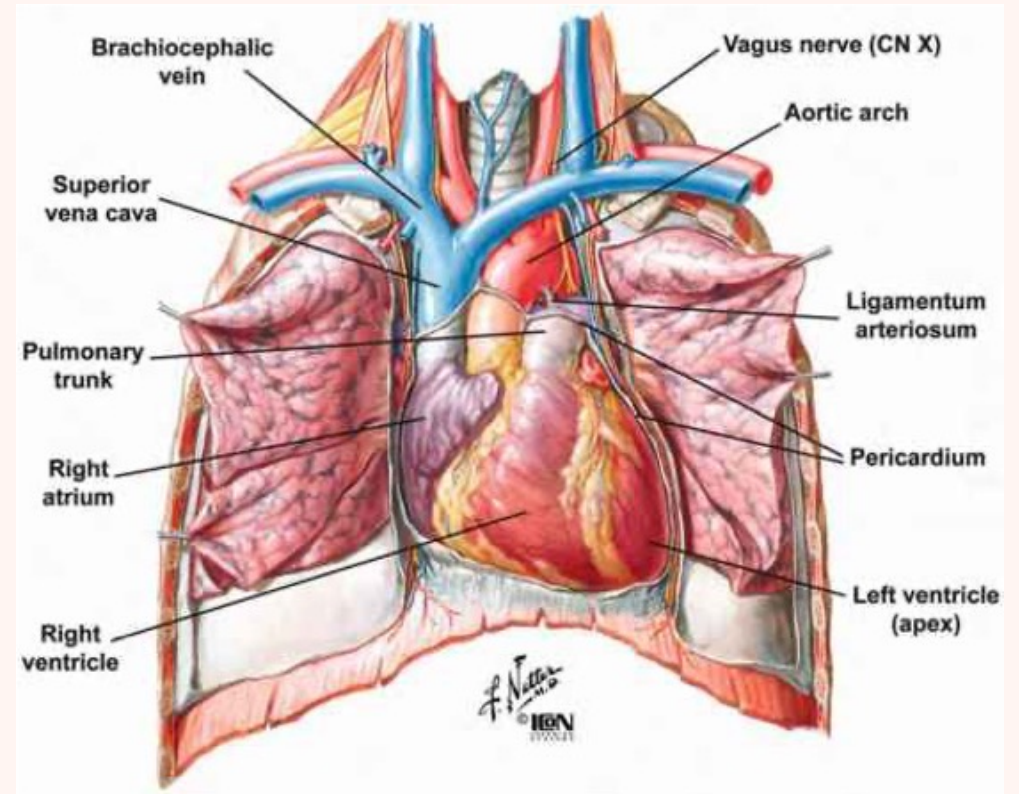
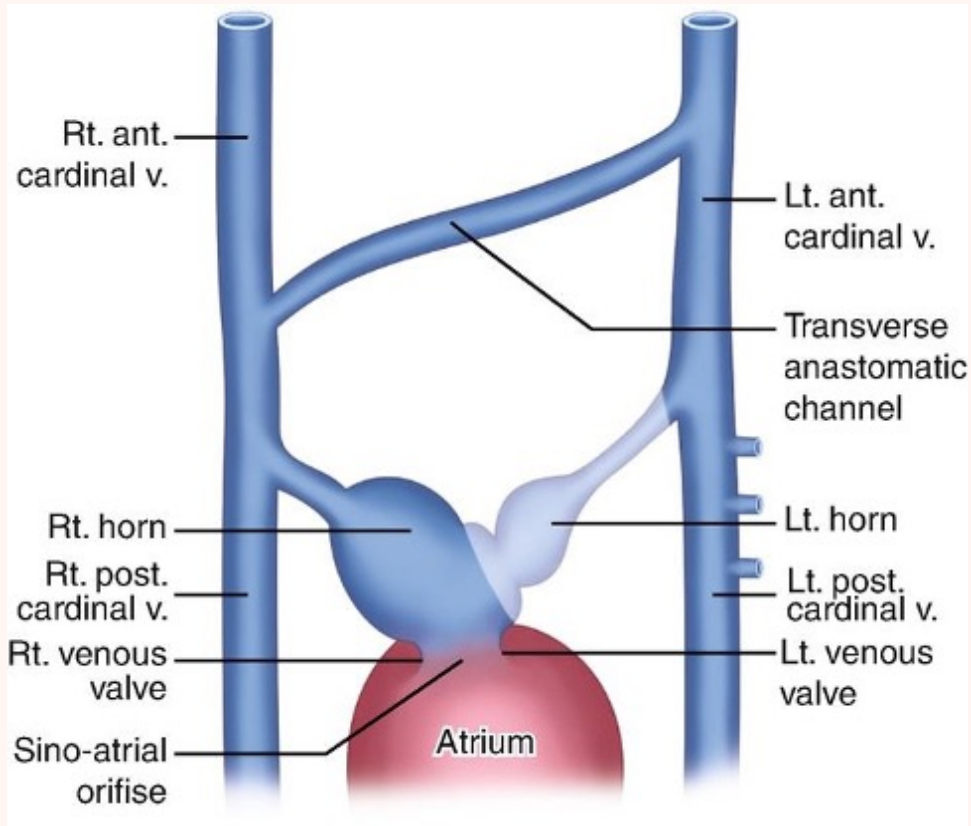
- **On the right side: it forms:**

- Right internal jugular vein.
- Right brachiocephalic vein.
- Distal part of superior vena cava.

- **On the left side: it forms:**

- Left internal jugular vein.
- Proximal part of the left superior intercostal vein.

- **The transverse connection** forms the left brachiocephalic vein.
-



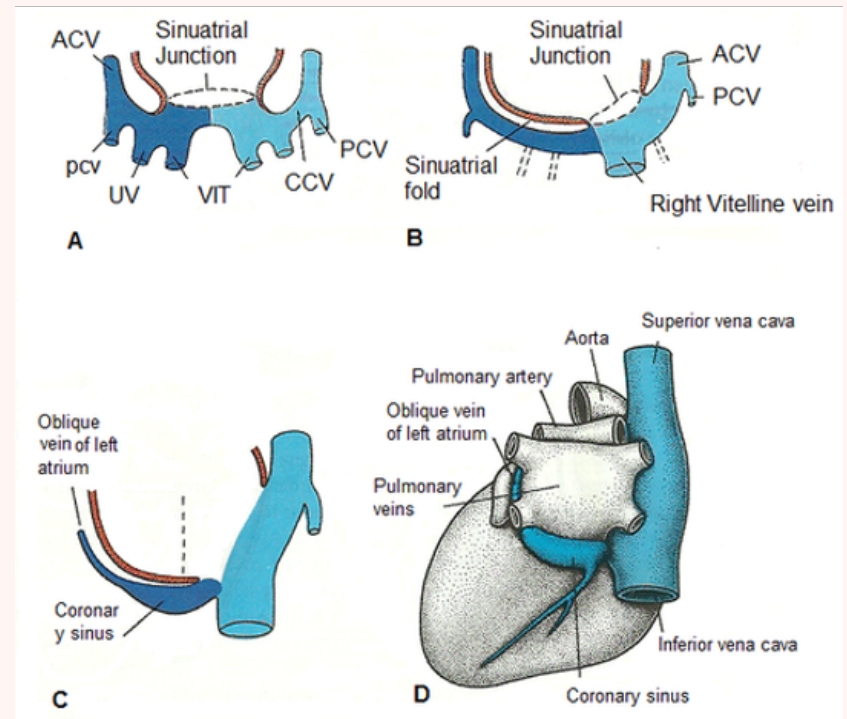
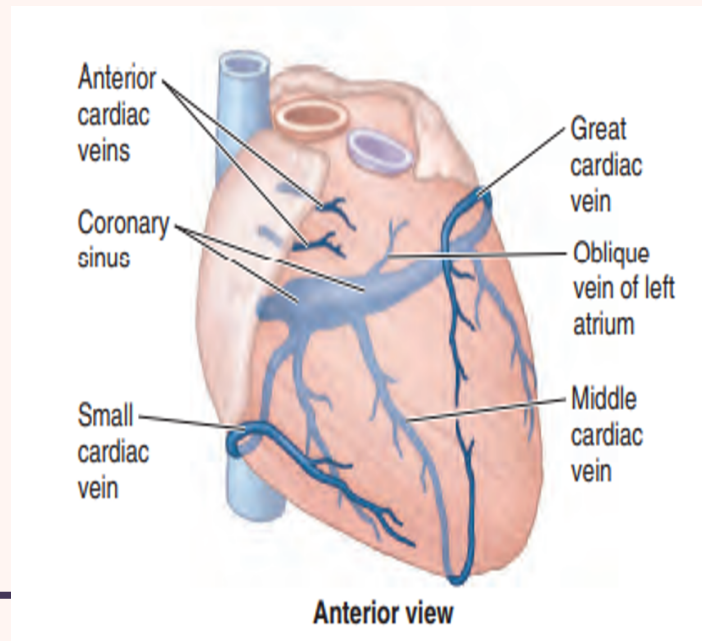
Common cardinal veins

Each vein is formed by union of the anterior and posterior cardinal veins.

Each one opens into the corresponding **horn of the sinus venosus**.

* **Fate :**

- **On the right side:** forms the proximal part of the **SVC**.
- **On the left side:** forms the **oblique vein** of left atrium.



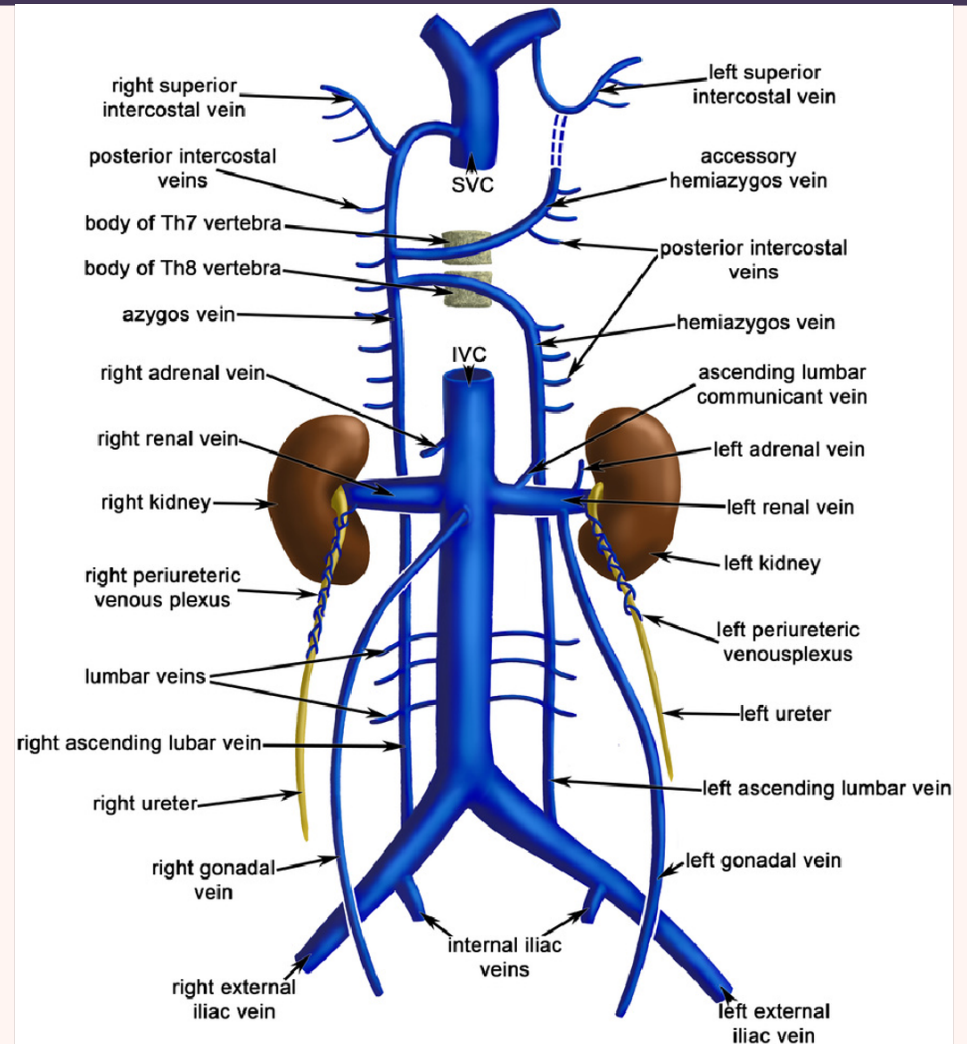
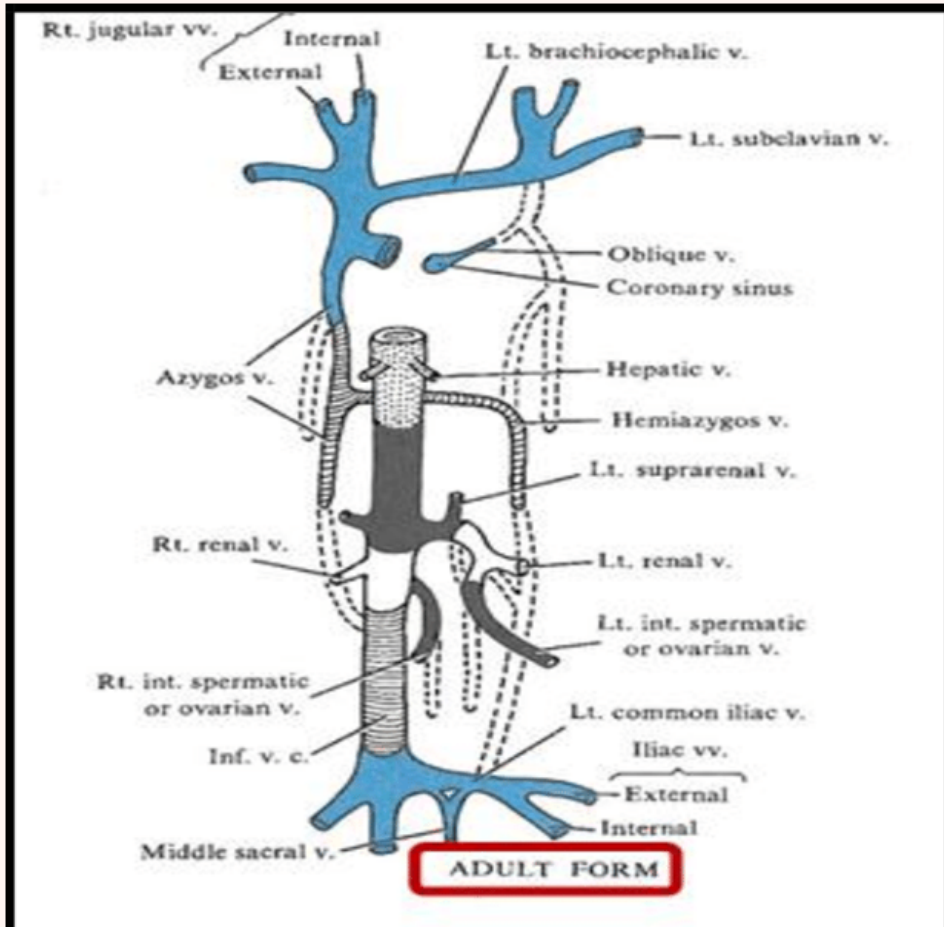
Posterior cardinal veins

- They lie one on each side and drain the **caudal part** of the embryo i.e. trunk and lower limbs.

- **Fate**

Right side It degenerates

Left side It degenerates except its cranial part which forms a part of the left superior intercostal vein.

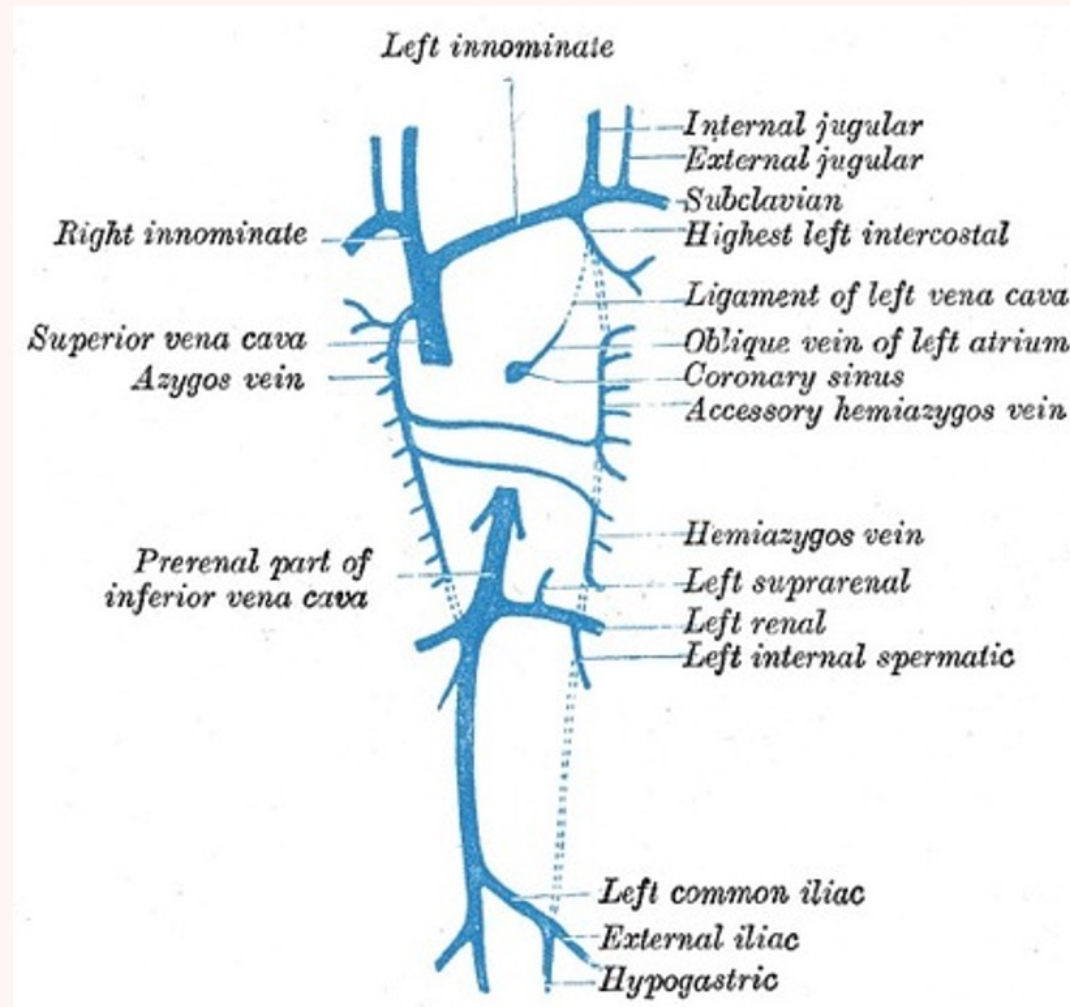


Supracardinal veins

- They lie, one on each side, dorsolateral to the aorta.
- The 2 supracardinal veins are connected by intersupracardinal anastomosis.

* **Fate :**

- **On the right side:** most of the azygos vein.
 - **On the left side:** form the superior and inferior hemiazygos veins.
 - The 2 transverse anastomoses form the connection between the hemiazygos veins and the azygos vein.
-



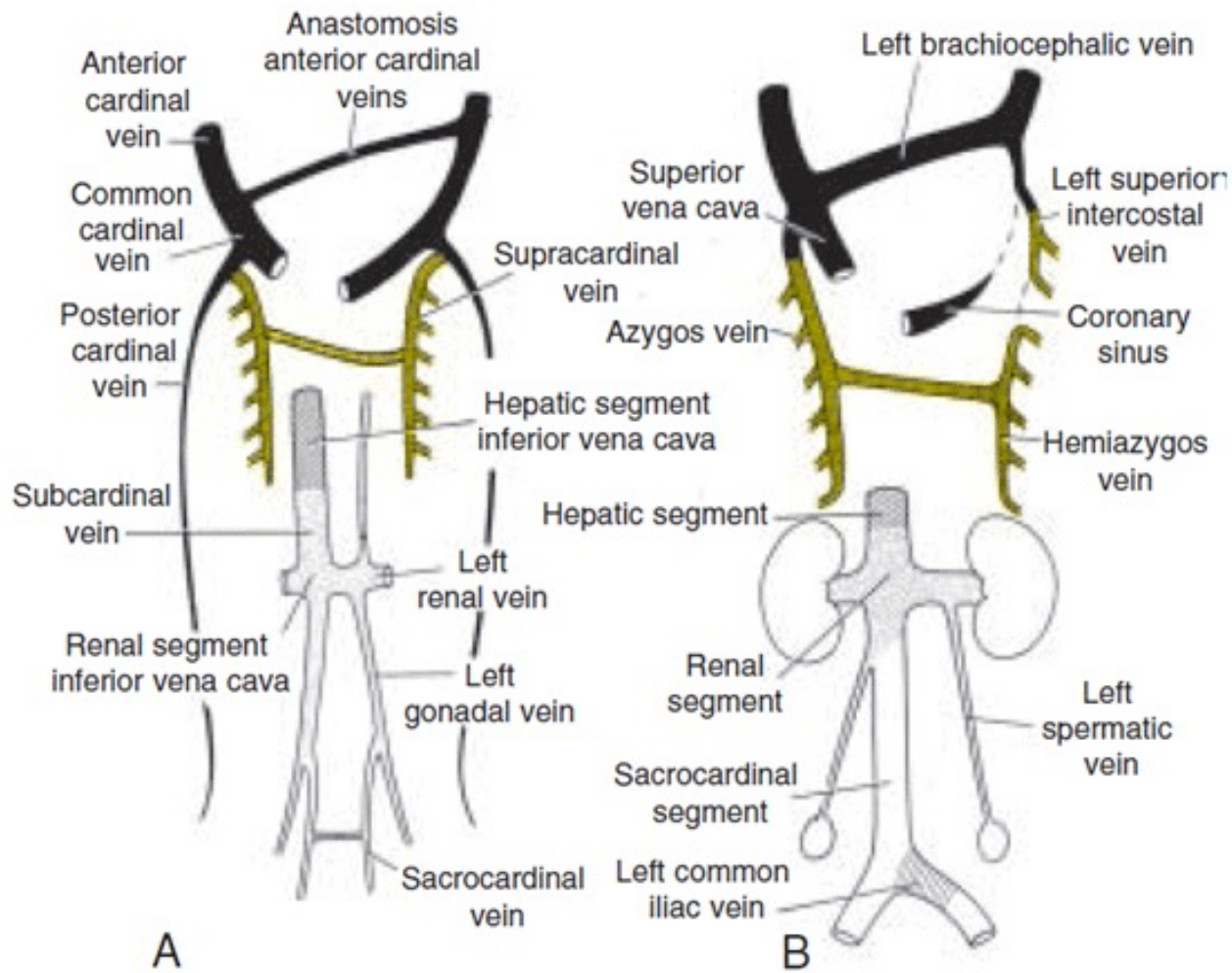
Subcardinal veins

- They lie, one on each side, ventrolateral to the abdominal aorta.
- The 2 subcardinal veins are connected together by intersubcardinal anastomosis.

* **Fate :**

- **On the right side:** forms renal part of I.V.C.
- **On the left side:** forms the left gonadal vein.

The intersubcardinal anastomosis forms left renal vein.



Sacrocardinal veins

The right sacrocardinal vein becomes the sacrocardinal segment of the inferior vena cava.

The anastomosis between the sacrocardinal veins forms the left common iliac vein

Development of inferior vena cava

The inferior vena cava develops from the following segments (from caudal to cranial):

- 1. Sacrocardinal segment:** Right sacrocardinal vein
 - 2. Renal segment :** Right subcardinal veins.
 - 3. Hepatic segment :** is derived from the right vitelline vein.
-

Congenital Anomalies:

1-**Left I.V.C:** occurs when the left sacrocardinal vein fails to lose its connection with the left subcardinal vein

2-**Absence of I.V.C.:** when the right subcardinal vein fails to make its connection with the liver and shunts its blood directly into the right supracardinal vein

Hence the bloodstream from the caudal part of the body reaches the heart by way of the azygos vein and superior vena cava.

3-**Left superior vena cava** is caused by persistence of the left anterior cardinal vein and obliteration of the common cardinal and proximal part of the anterior cardinal veins on the right

In such a case, blood from the right is channeled toward the left by way of the brachiocephalic vein. The left superior vena cava drains into the right atrium by way of the left sinus horn, that is, the coronary sinus.

4-A **double superior vena cava** is characterized by the persistence of the left anterior cardinal vein and failure of the left brachiocephalic vein to form. The persistent left anterior cardinal vein, the **left superior vena cava**, drains into the right atrium by way of the coronary sinus.

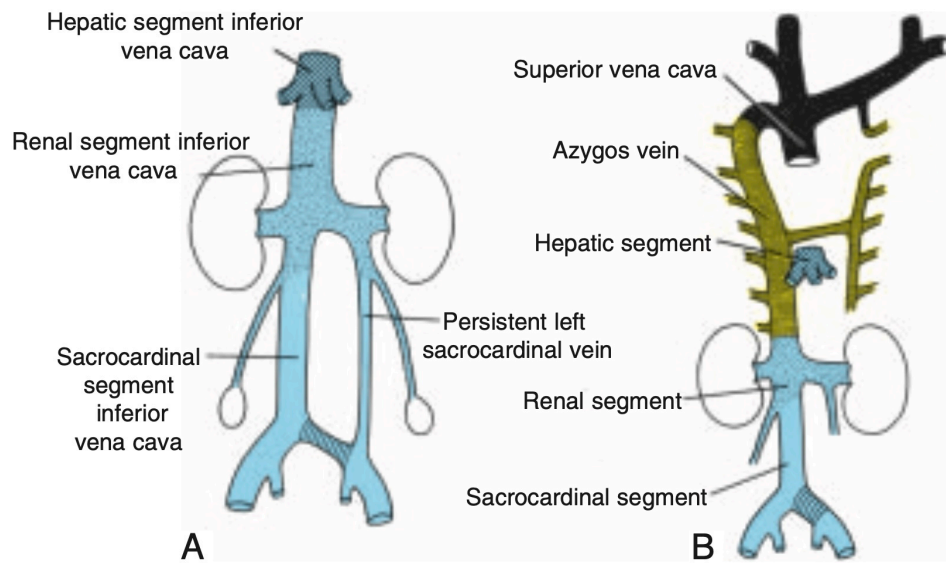


Figure 11.45 A. Double inferior vena cava at the lumbar level arising from the persistence of the left sacrocardinal vein. **B.** Absent inferior vena cava. The lower half of the body is drained by the azygos vein, which enters the superior vena cava. The hepatic vein enters the heart at the site of the inferior vena cava.

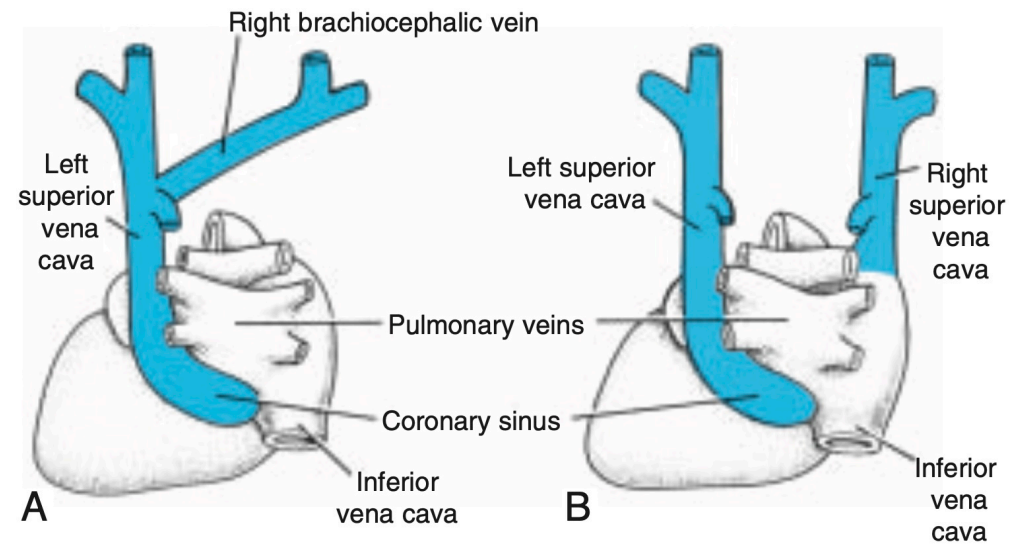


Figure 11.46 A. Left superior vena cava draining into the right atrium by way of the coronary sinus (dorsal view). **B.** Double superior vena cava. The communicating (brachiocephalic) vein between the two anterior cardinals has failed to develop (dorsal view).

FETAL CIRCULATION

I) The oxygenated blood :

- The oxygenated blood is carried from placenta to the fetus by left umbilical vein which passes to liver → the blood passes mainly through the **ductus venosus** to reach the I.V.C.
→ the blood passes to the right atrium → Then it passes to left atrium through the foramen ovale due to :

- ✱ The valve of IVC directs blood to the foramen ovale

- ✱ The pressure inside right atrium is higher than left atrium .

Then the blood passes from left atrium to the left ventricle → to the arch of aorta where it is distributed mainly to the head & neck and upper limbs.

II) The deoxygenated blood:

Blood from the upper 1/2 of the body carried by the S.V.C.: reaches the right atrium where it passes directly to the right ventricle → then the blood passes to the pulmonary trunk → then it passes through the **ductus arteriosus** to reach the distal part of arch of aorta → descending aorta → mainly umbilical arteries → to the placenta (and to less extent to the lower part of the body).

Blood from the lower 1/2 of the body carried by the I.V.C. Where it is mixed with the oxygenated blood .

III) Changes in the circulation after birth :

A) Immediate changes :

1) Establishment of pulmonary circulation: Immediately after birth, respiration starts and lungs expand.

2) Functional closure of the foramen ovale: Closure of foramen ovale occurs as a result of firm apposition of septum primum to septum secundum due to:

- Increased pressure inside left atrium (due to establishment of the pulmonary circulation).
 - Decreased pressure inside the right atrium (due to arrest of the placental blood flow).
-

3) Functional closure of ductus arteriosus immediately after birth by contraction of its muscular wall.

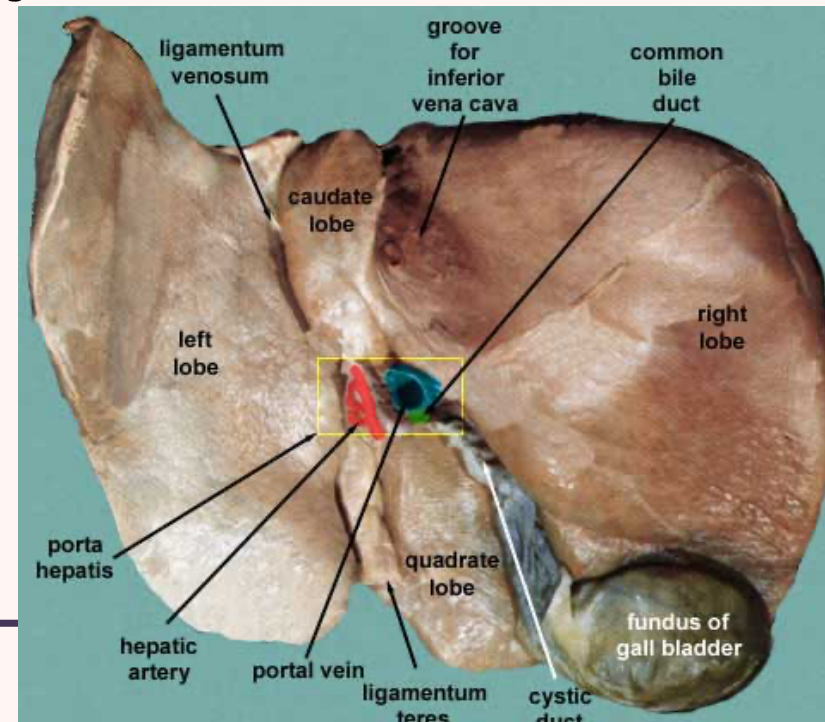
B) Late fibrotic changes :

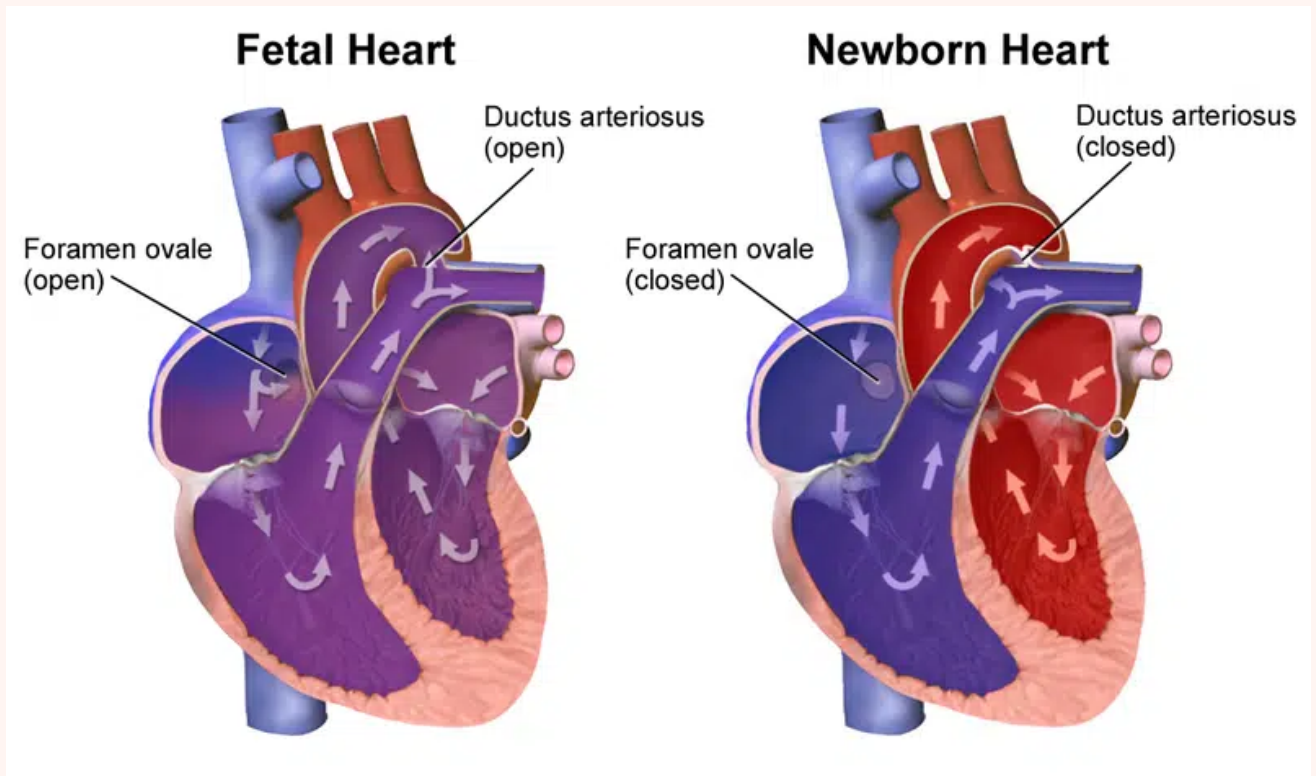
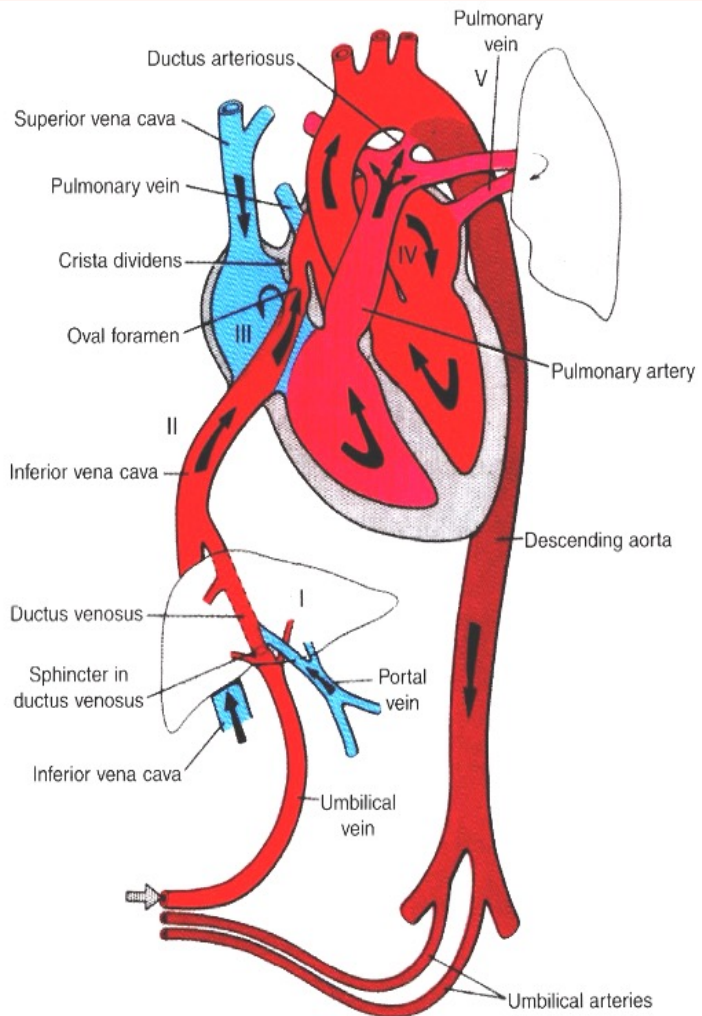
1) Left umbilical vein: becomes the ligamentum teres of the liver.

2) Ductus venosus: becomes the ligamentum venosum of the liver.

3) Ductus arteriosus: becomes the ligament arteriosus.

4) Distal part of umbilical arteries: become the medial umbilical ligaments.







THANK YOU
