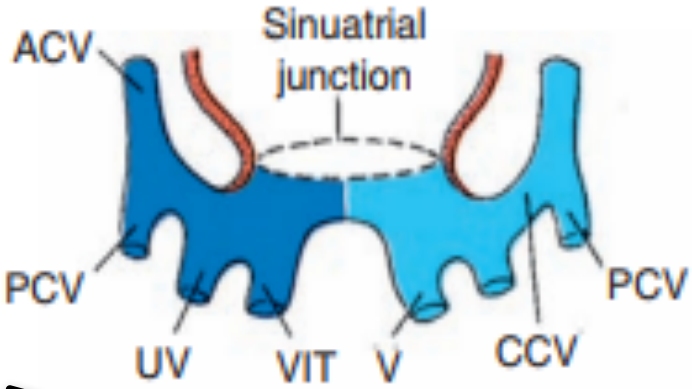
Development of Major Blood Vessels

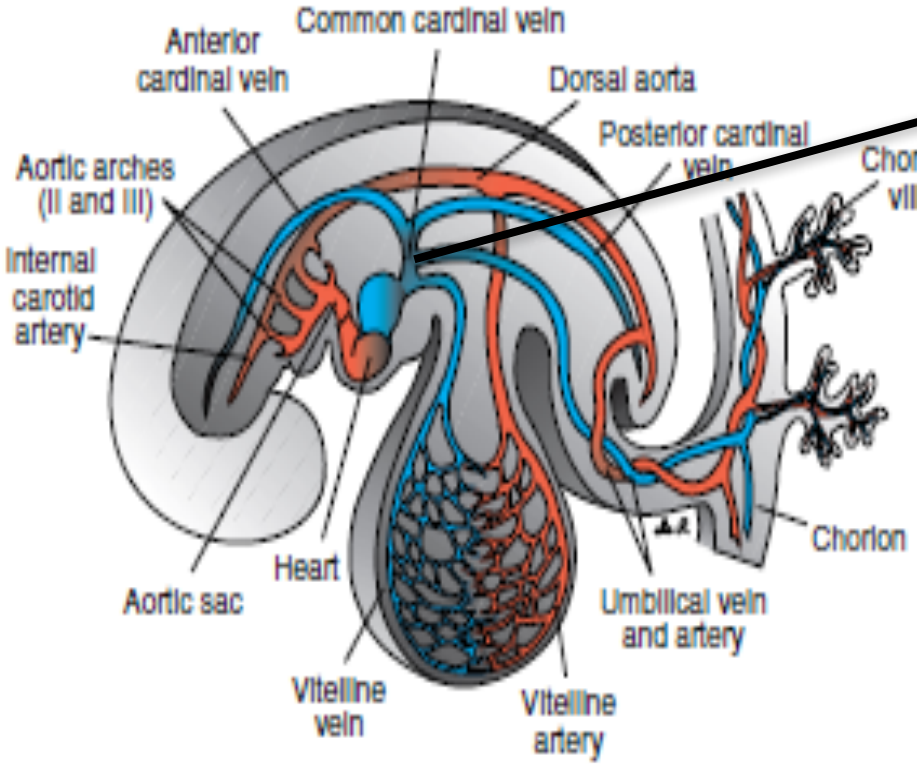
The sinus venosus represent the venous end of the heart
It receives 3 veins:

1- Common cardinal vein → body wall

2- Umbilical vein → from placenta

3- Vitelline vein → from yolk sac

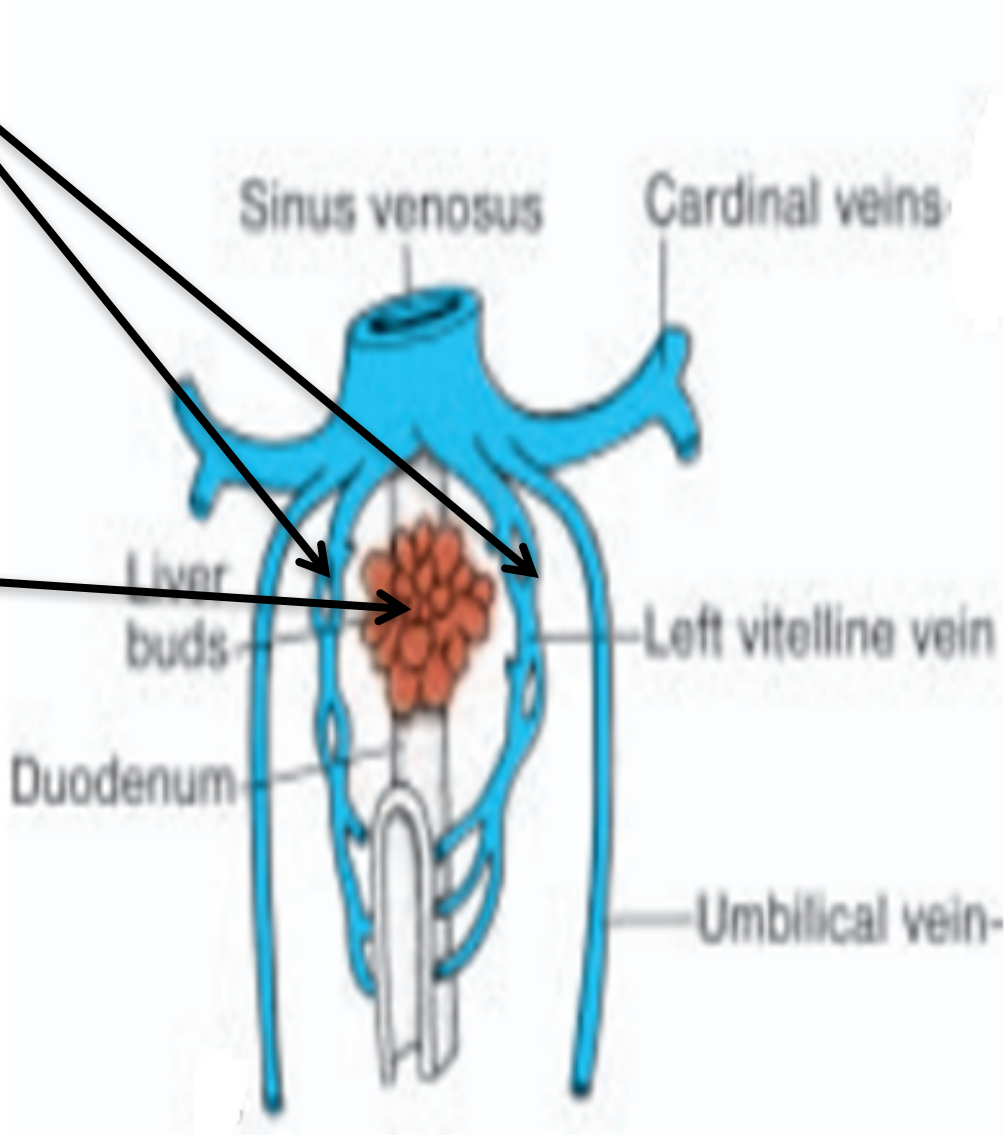




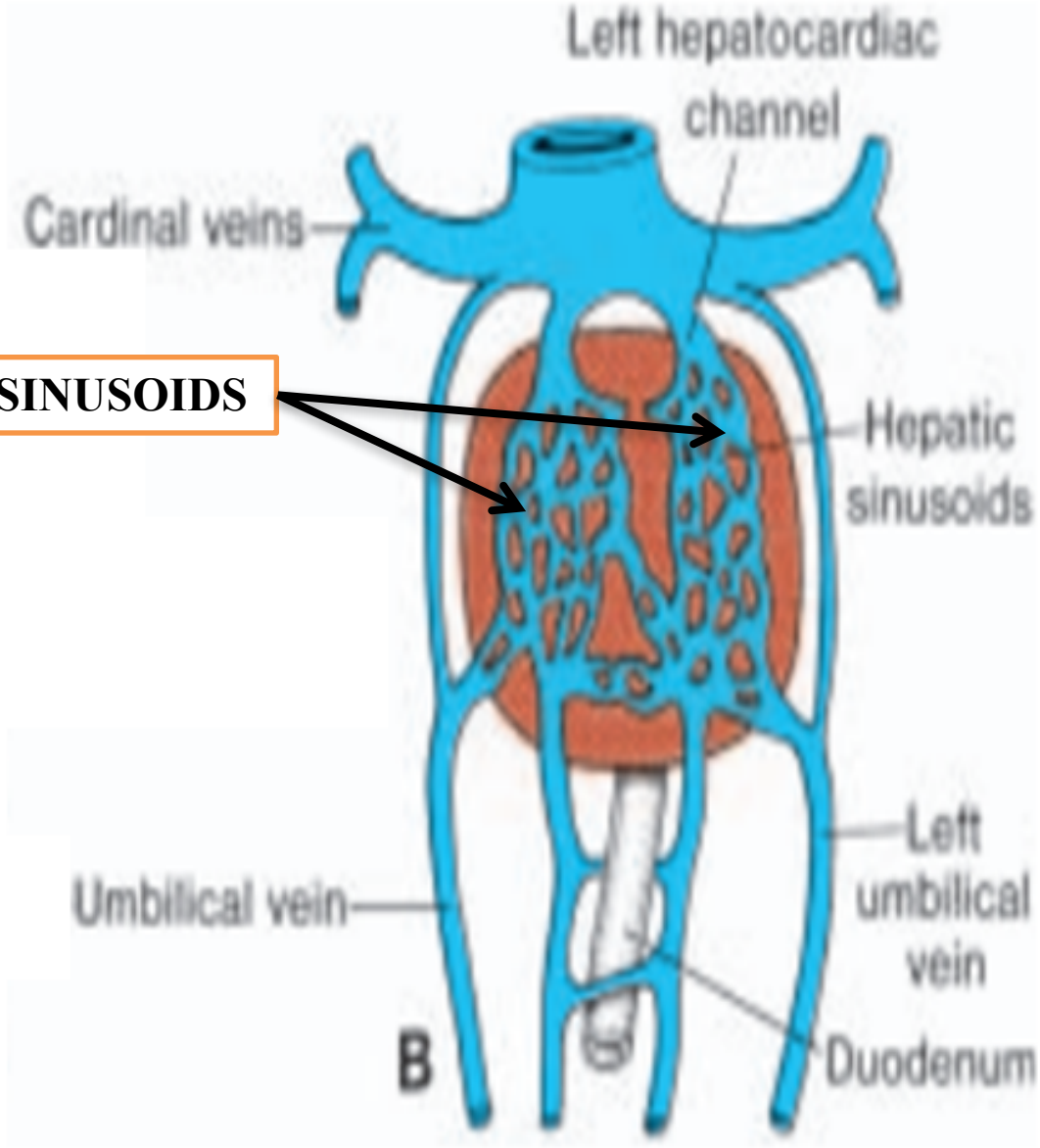
A-Vitelline Veins (omphalomesenteric) veins

1-The vitelline veins form a plexus around the developing duodenum then it enters the sinus venosus

2-The growing liver cords interrupt the course of the vitelline veins, and form an extensive vascular network

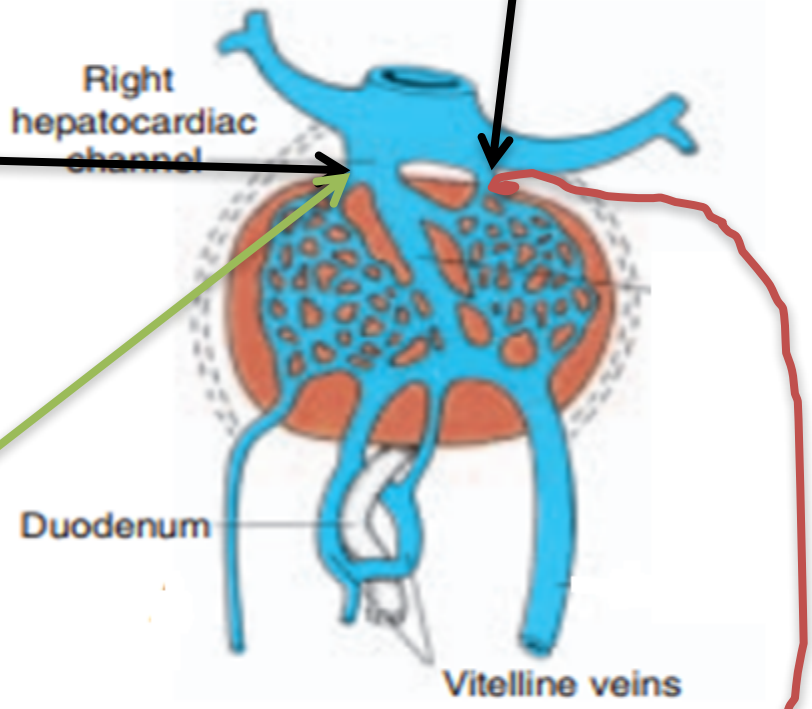


THE HEPATIC SINUSOIDS



It should be noted that at this time **the left sinus horn** of the sinus venosus is loosing its importance and blood from the left side of the liver is rechanneled toward the right, resulting in an enlargement of the right vitelline vein Also called **(right hepatocardiac channel)**

Notice how the left vitelline vein Is redirected to the right vitelline vein which is in its turn getting bigger



3-The right hepatocardiac channel forms the hepatocardiac portion of

The inferior vena cava

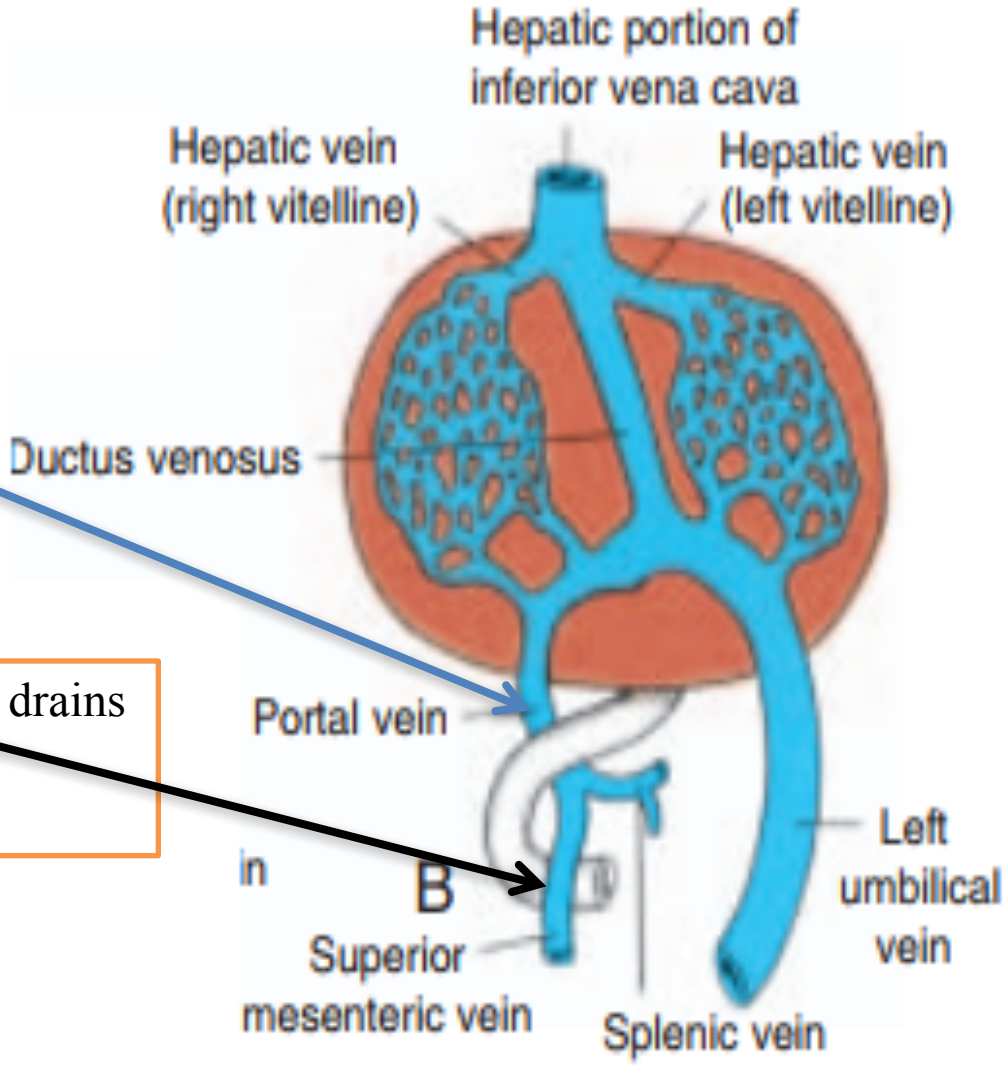
4-The proximal part of the left vitelline vein disappears

5- The anastomotic network around the duodenum develops into a single vessel,

The portal vein

6- The **superior mesenteric vein**, which drains the primary intestinal loop, derives **from the right vitelline vein**

7- The distal portion of the left vitelline vein also disappear



You should know by now;
1-the origin of all of the following:

Right vitelline vein

- **THE HEPATIC SINUSOIDS**
- The hepatocardiac portion of **the inferior vena cava**
- **The portal vein**
- The **superior mesenteric vein**

2- what is the fate of the left vitelline vein

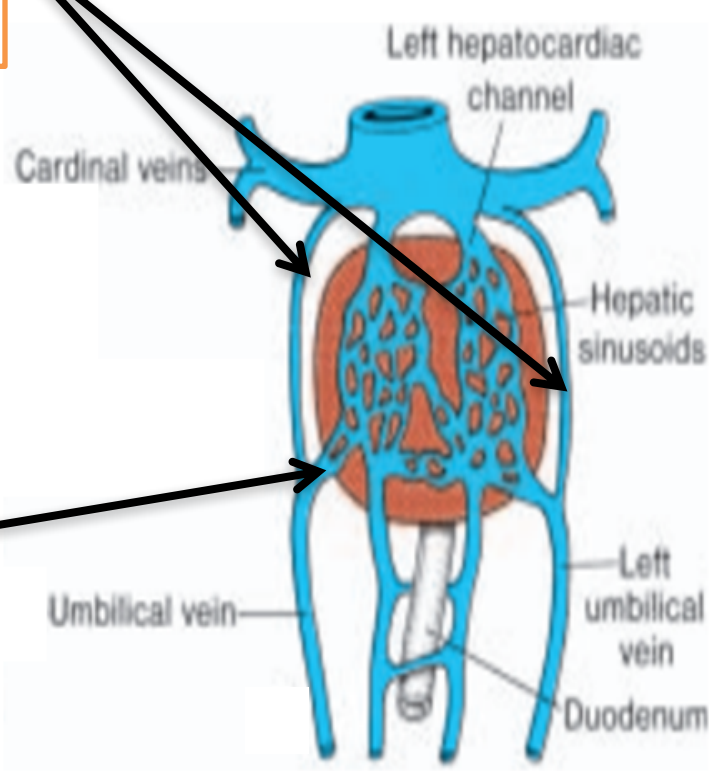
Left vitelline vein

- The proximal part of the left vitelline vein disappear
- The distal portion of the left vitelline vein also disappear

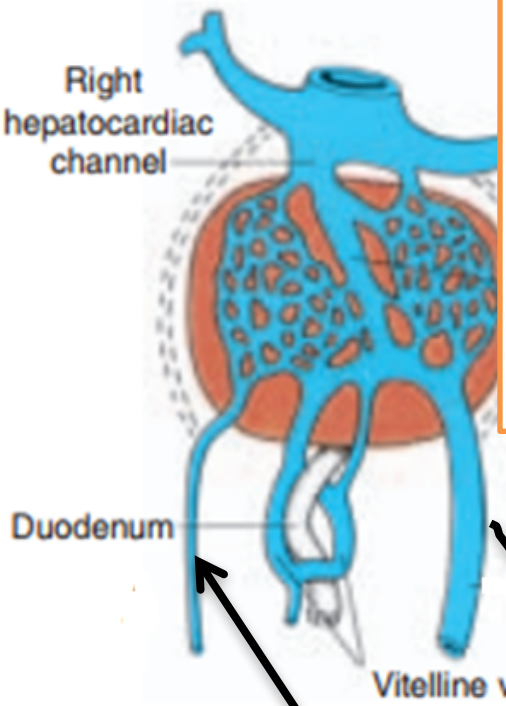
B-Umbilical Veins

1-Initially the umbilical veins pass on each side of the liver

2-Some connect to the hepatic sinusoids



A



B

3-The proximal part of both umbilical veins disappear

No connection between the sinus venosus and the umbilical veins

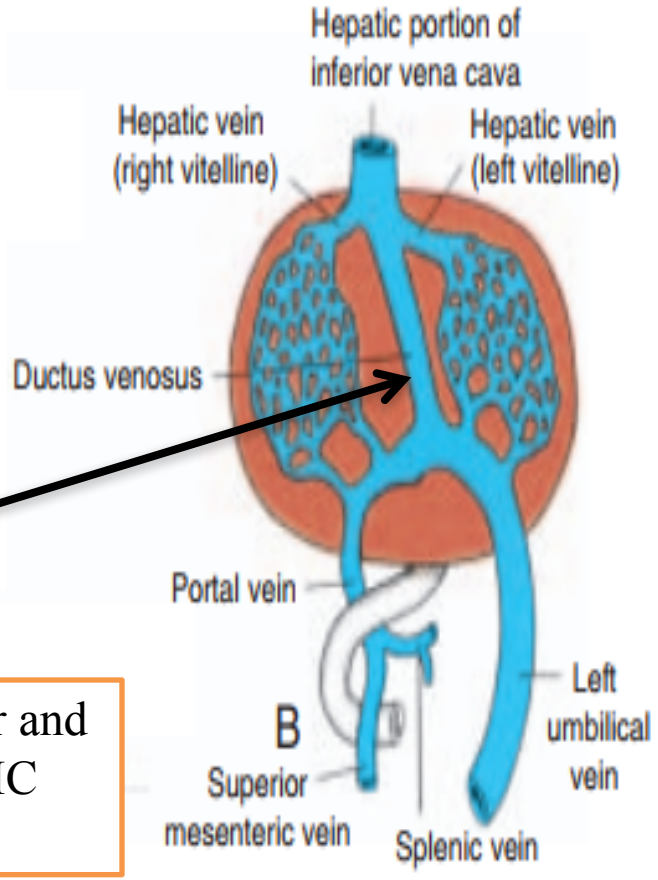
How they will connect?

4-The remainder of the right umbilical vein then disappear, so that **the left vein** is **the only one** to carry blood from the placenta to the liver

Compare between umbilical veins in A and B

5-With the increase of the placental circulation, a direct communication forms between
the left umbilical vein
and
the right hepatocardiac channel
To Form

The ductus venosus

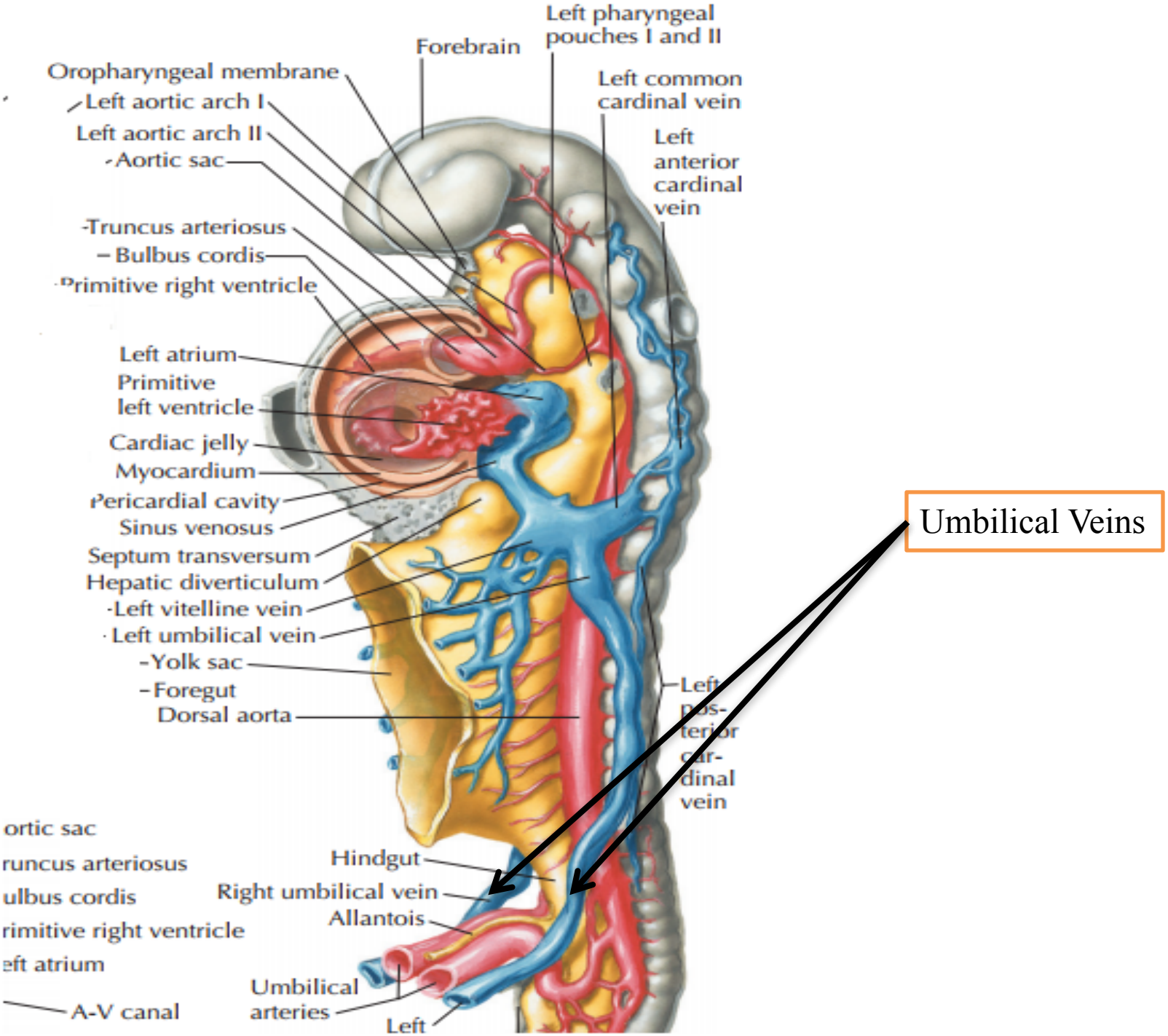


This vessel bypasses the sinusoidal plexus of the liver and directly connects the left umbilical vein to HEPATIC PORTION OF THE INFERIOR VENA CAVA

6- After birth the left umbilical vein and ductus venosus are **obliterated**

left umbilical vein forms…….. the ligamentum teres hepatis

ductus venosus forms……the ligamentum venosum


Left pharyngeal pouches I and II
Forebrain
Oropharyngeal membrane
Left common cardinal vein
Left aortic arch I
Left aortic arch II
Left anterior cardinal vein
Aortic sac
Truncus arteriosus
Bulbus cordis
Primitive right ventricle
Left atrium
Primitive left ventricle
Cardiac jelly
Myocardium
Pericardial cavity
Sinus venosus
Septum transversum
Hepatic diverticulum
Left vitelline vein
Left umbilical vein
Yolk sac
Foregut
Dorsal aorta
Left posterior cardinal vein
Hindgut
Right umbilical vein
Allantois
Umbilical arteries
Left
ortic sac
runcus arteriosus
ulbus cordis
rimitive right ventricle
eft atrium
A-V canal
Umbilical Veins

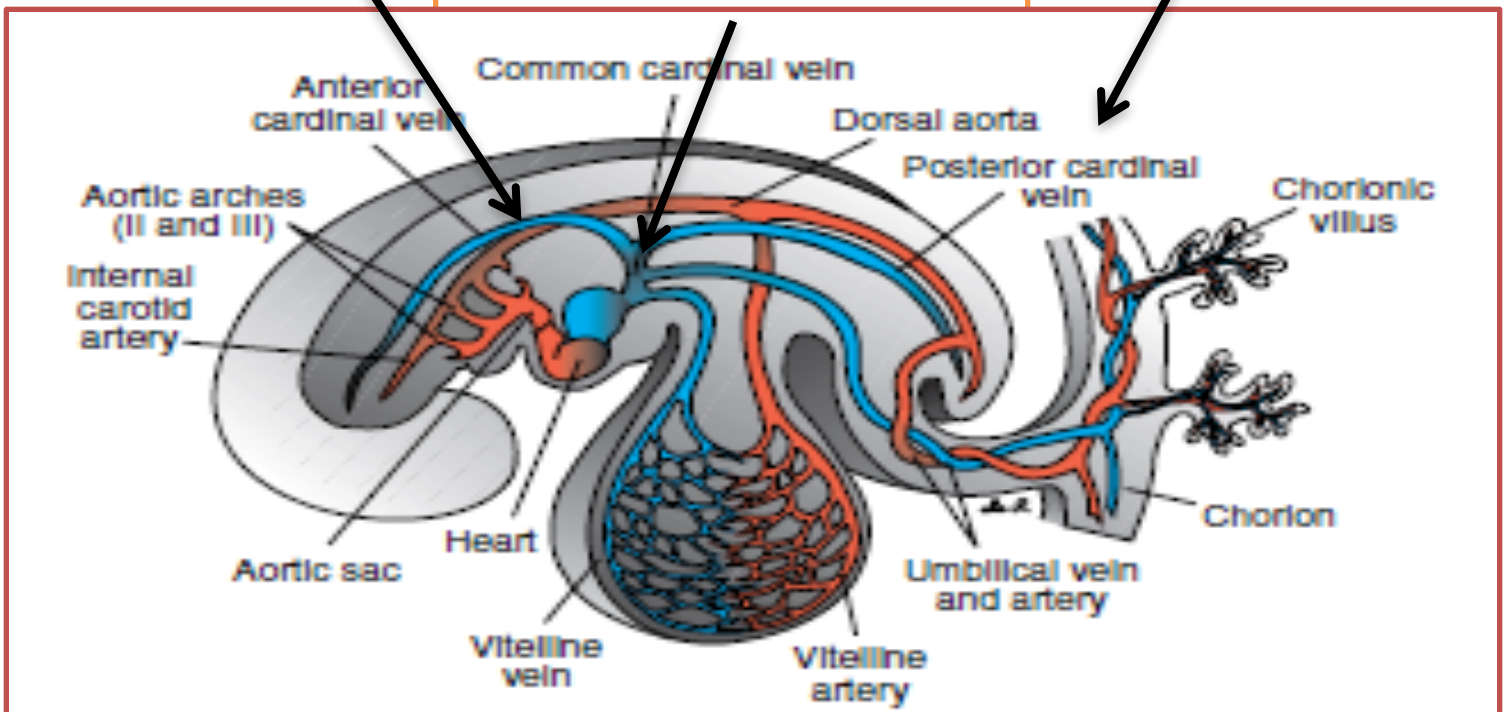
C- Cardinal Veins

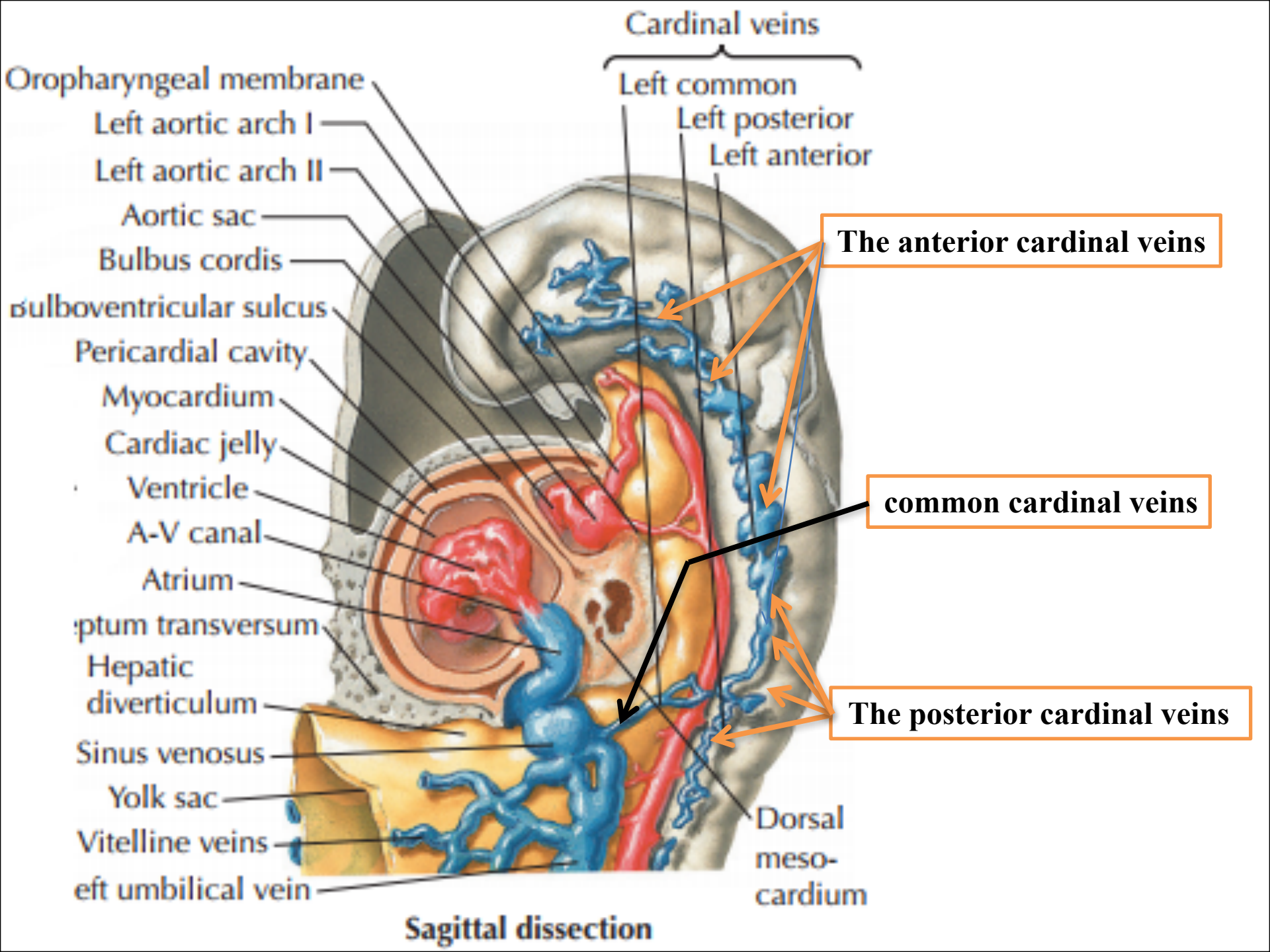
1-This system consists of:

Right and left anterior cardinal veins which drain the cephalic part of the embryo

Right and left posterior cardinal veins which drain the rest of the embryo

join before entering the sinus horn and form the short **right and left common cardinal veins**





Sagittal dissection

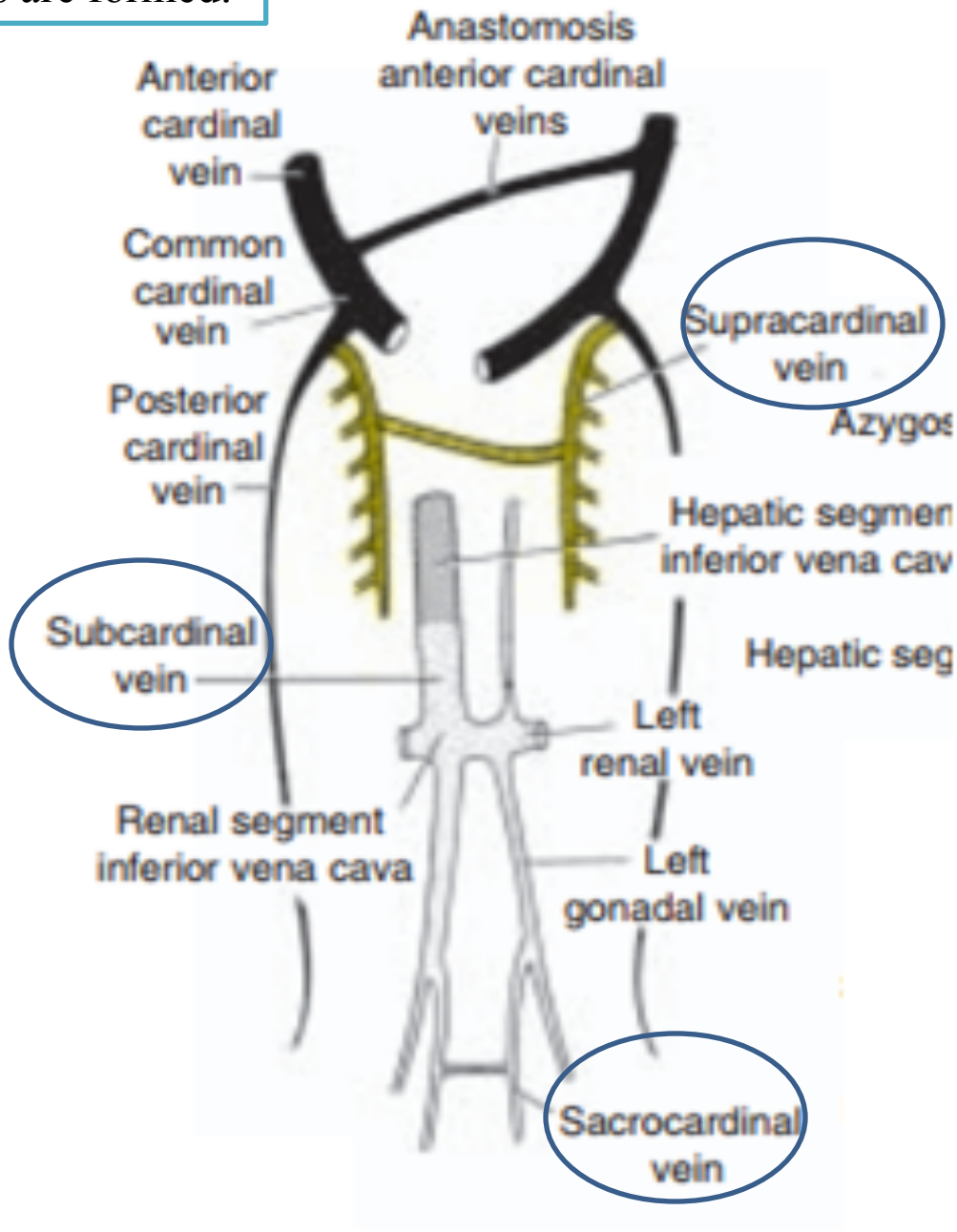
additional veins are formed:

2- During the fourth week, the cardinal veins form a symmetrical system During the fifth to the seventh week a number of additional veins are formed:

(a) The subcardinal veins
which mainly drain the kidneys

(b) The sacrocardinal veins
which drain the lower extremities

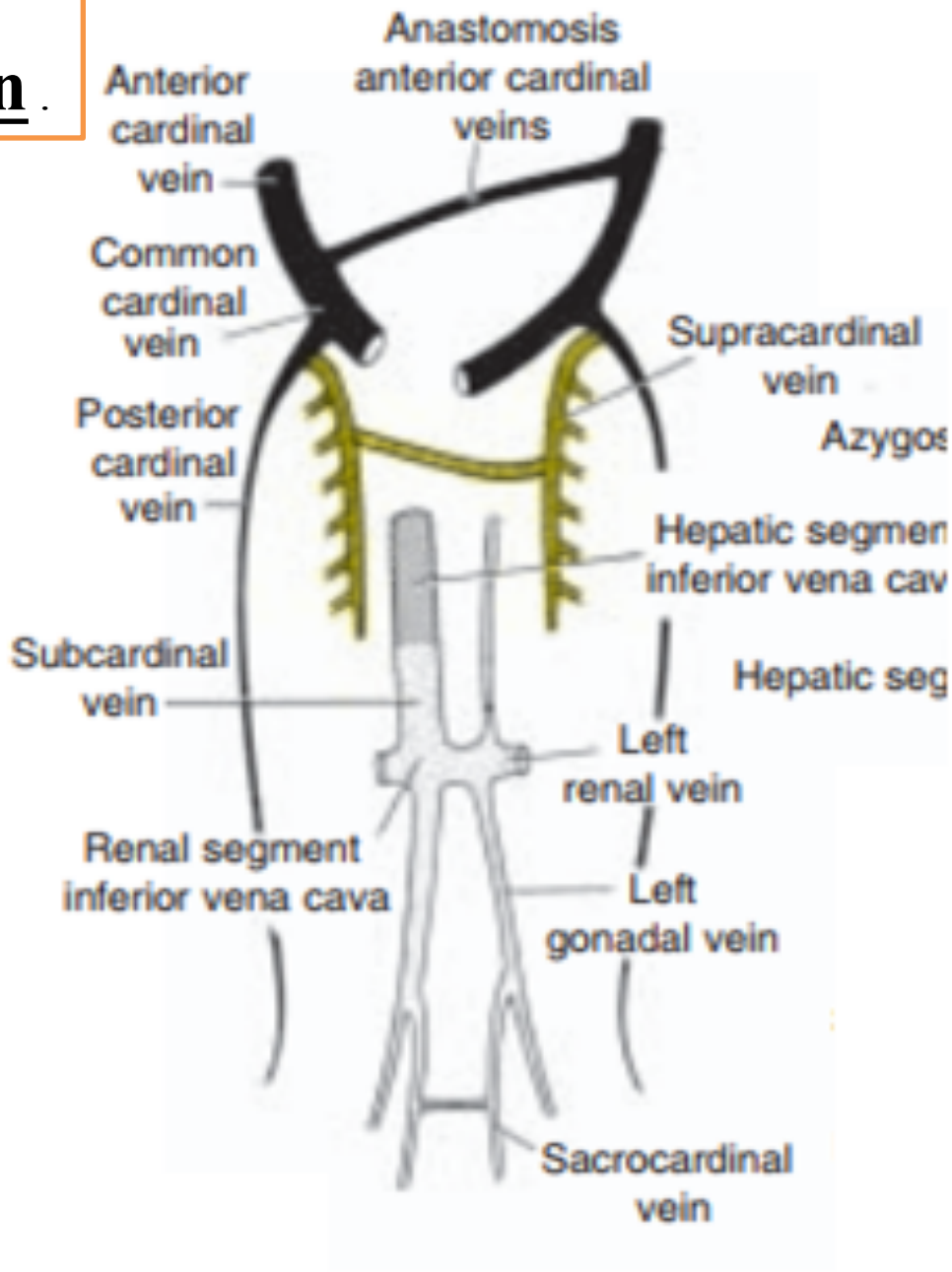
(c) The supracardinal veins
which drain the body wall by way of the intercostal veins, taking over the functions of the posterior cardinal veins



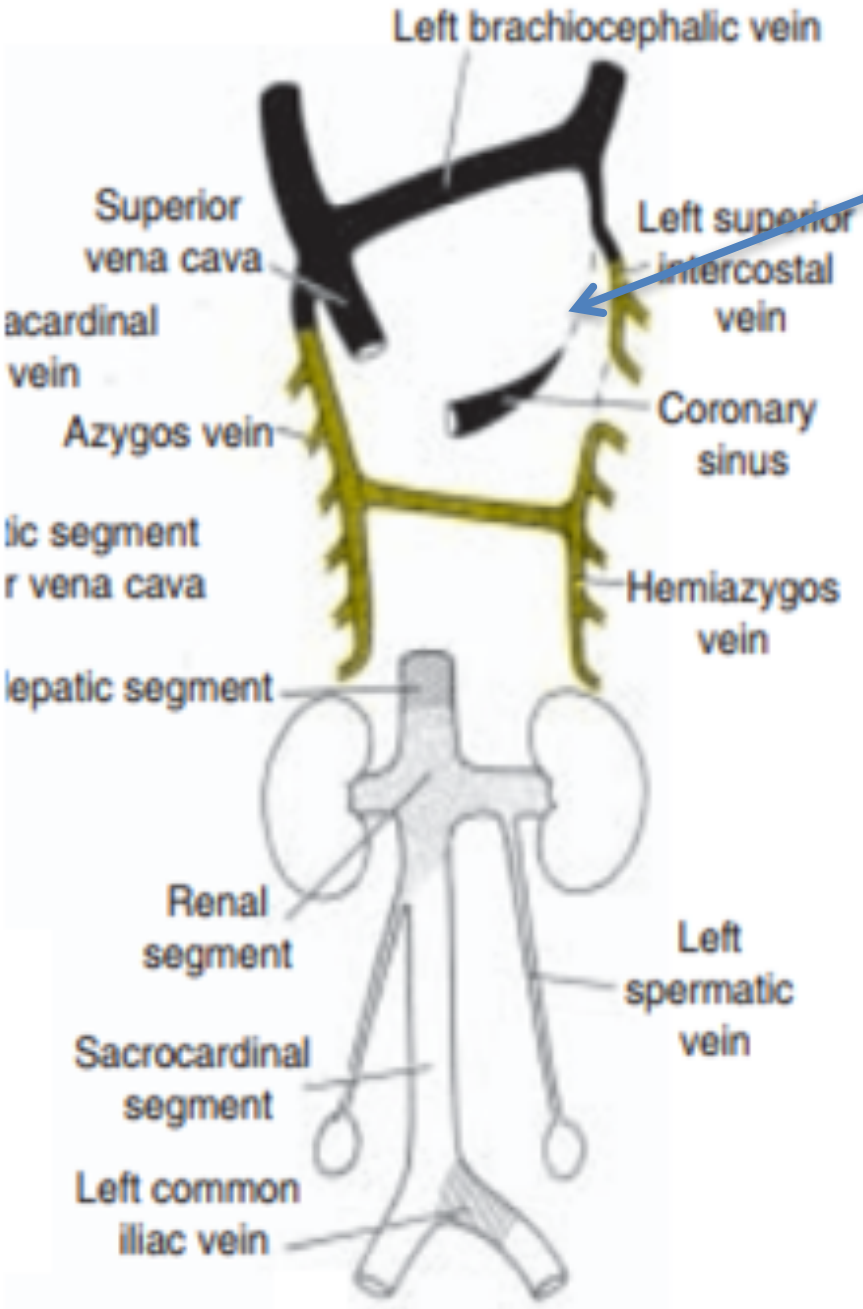
3-The anastomosis between the anterior cardinal veins develops into

the left brachiocephalic vein .

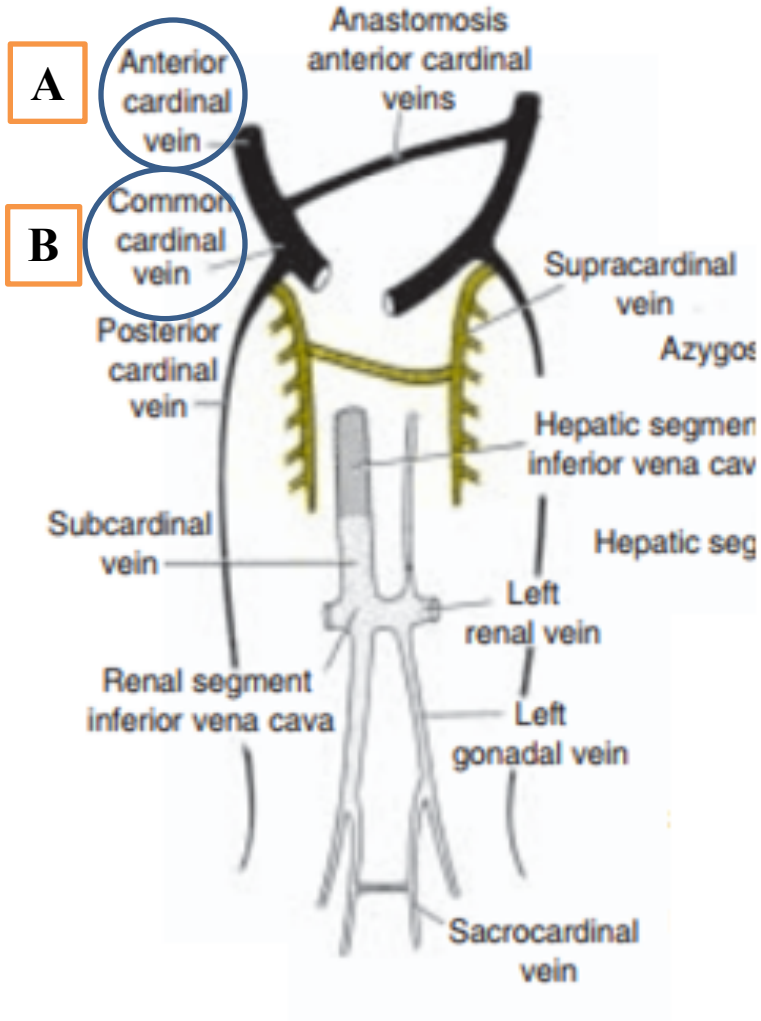
4- Most of the blood from the left side of the head and the left upper extremity is then channeled to the right

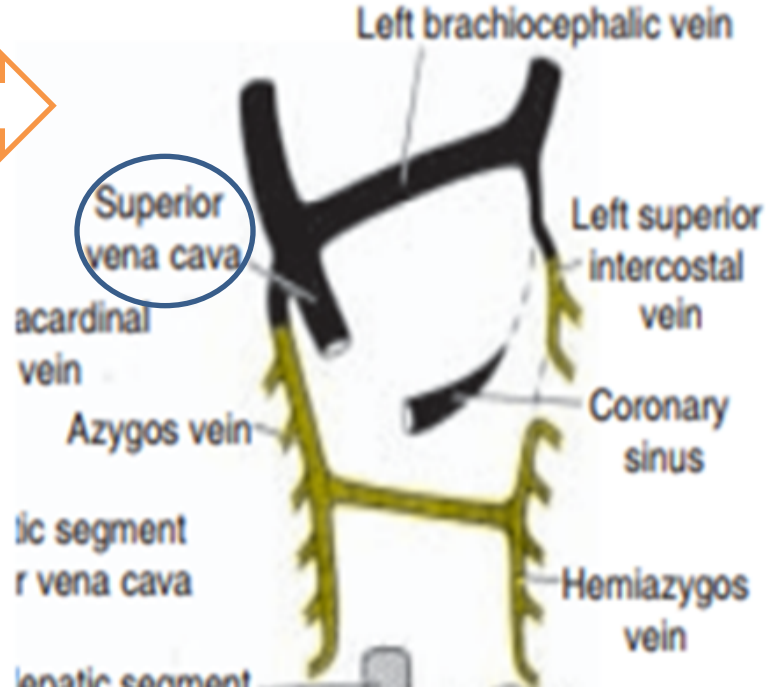


5- **The terminal portion** of the left posterior cardinal vein entering into the left brachiocephalic vein is retained as a small vessel, **the left superior intercostal** vein This vessel receives blood from the second and third intercostal spaces



6- **The superior vena cava** is formed
by
A-The right common cardinal vein
B-The proximal portion of the right anterior cardinal vein





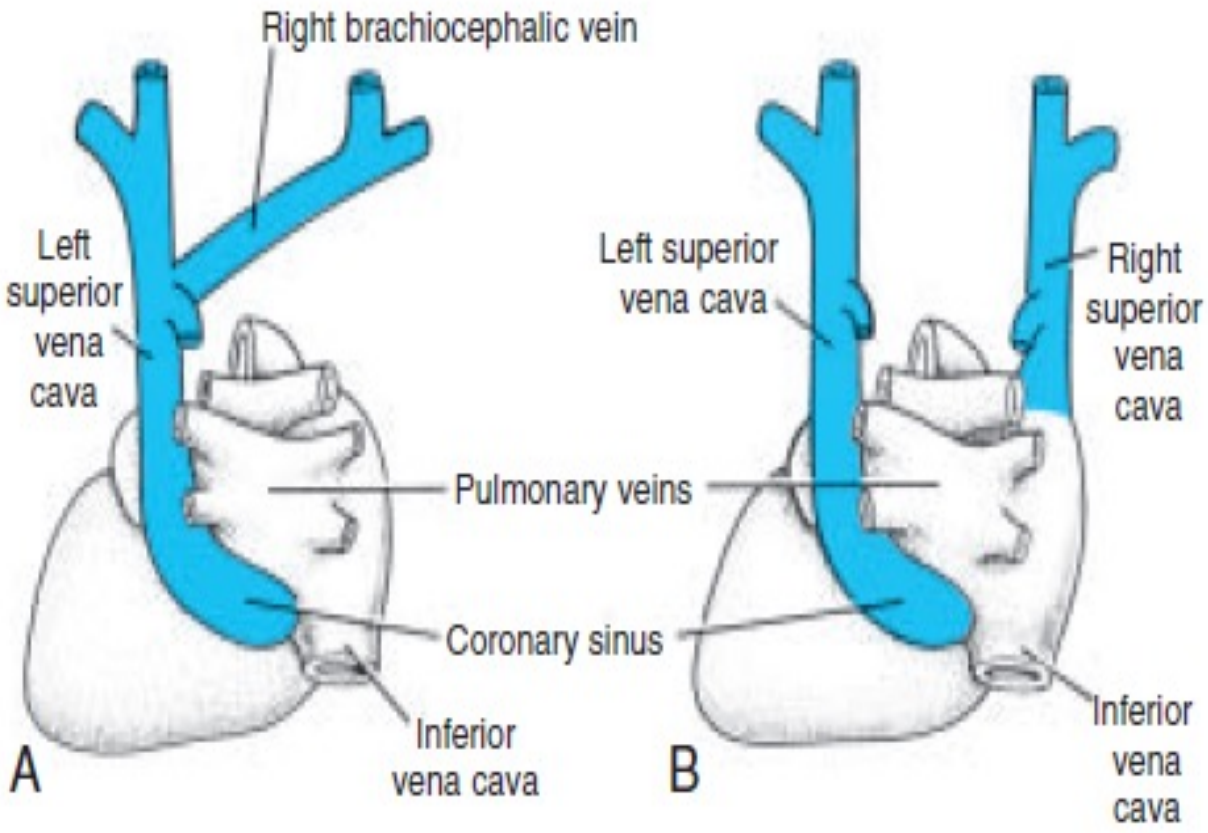
Clinical correlates

Left superior vena cava:

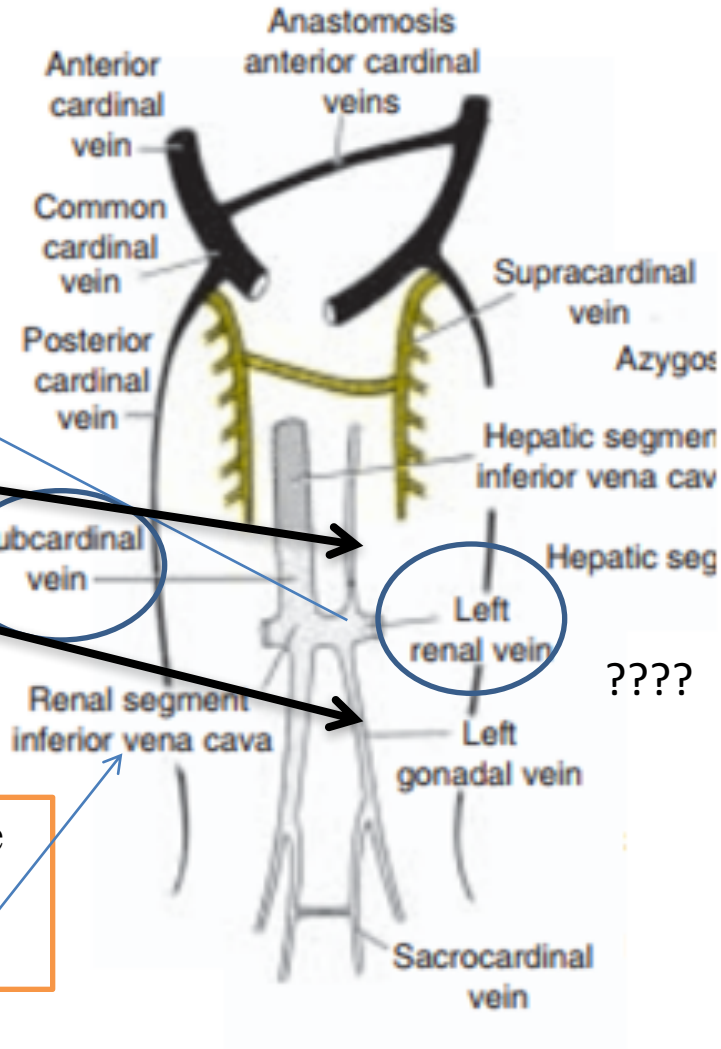
Persistence of the left anterior cardinal vein
Obliteration of the common cardinal and anterior cardinal veins on the right

Double superior vena cava:
Persistence of the left anterior cardinal vein

Failure of the right brachiocephalic vein to form



7- The anastomosis between the **subcardinal veins** ***forms*** ***the left renal vein.*** When this communication has been established, **the left subcardinal vein** disappears, and only its distal portion remains as **the left gonadal vein.**



Hence the right subcardinal vein becomes the main drainage channel and develops **into the renal segment** ***of the inferior vena cava***

8- The anastomosis between the sacrocardinal veins forms

The left common iliac vein

The right sacrocardinal vein becomes **sacrocardinal segment of the inferior vena cava**. When the renal segment of the inferior vena cava connects with the hepatic segment, which is derived from the right vitelline vein, the inferior vena cava**, consisting of hepatic, renal, and sacrocardinal segments, is complete**

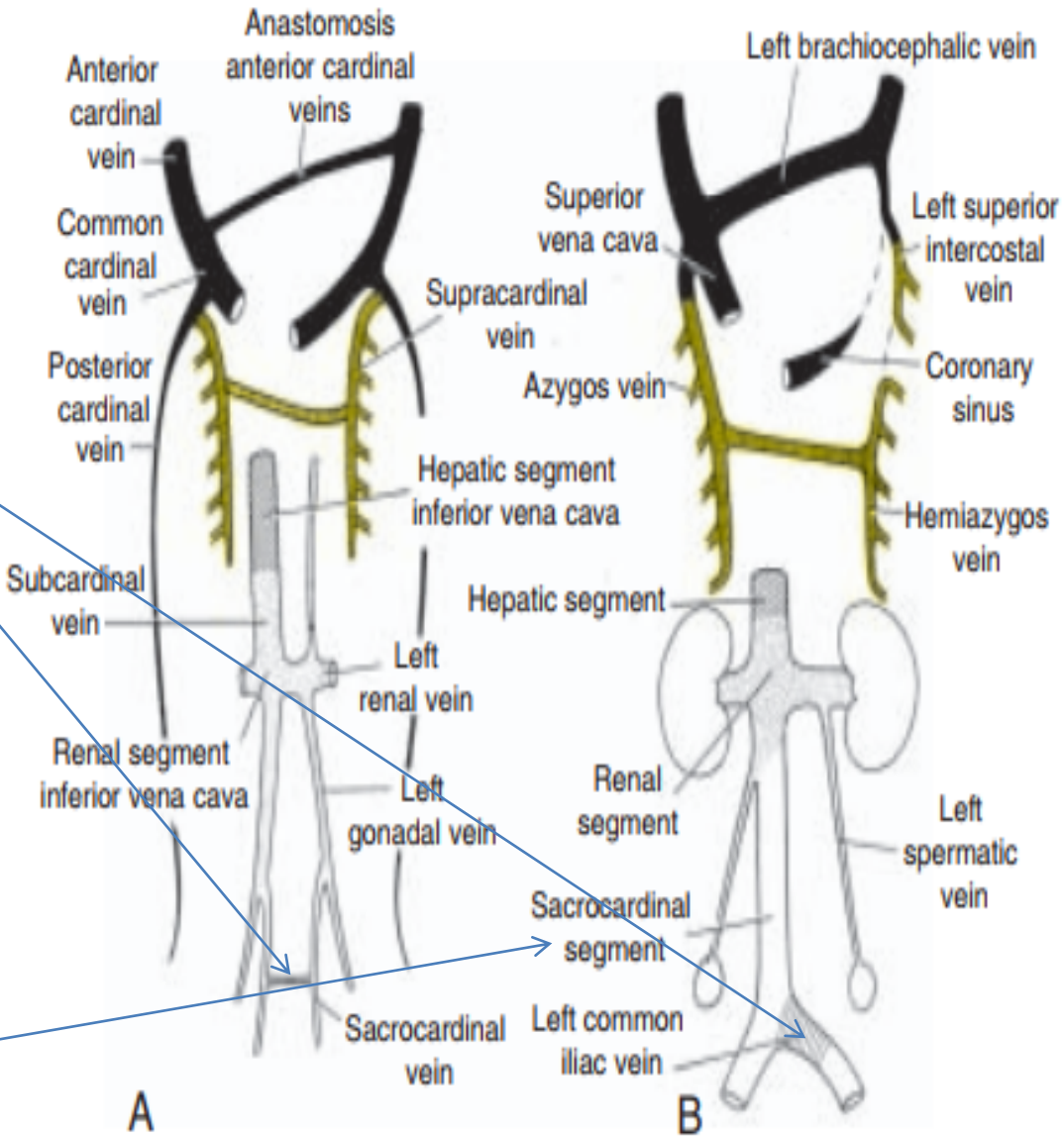


Figure 11.44 Development of the inferior vena cava, azygos vein, and superior vena cava. **A.** Seventh week. The anastomosis lies between the subcardinals, supracardinals, sacrocardinals, and anterior cardinals. **B.** The venous system at birth showing the three components of the inferior vena cava.

9- With obliteration of the major portion of the posterior cardinal veins, the supracardinal veins assume a greater role in draining the body wall. The 4th to 11th right intercostal veins empty into **the right supracardinal vein**, which together **with a portion of the posterior cardinal vein forms the azygos vein**

10- On the left the 4th to 7th intercostal veins enter into the left supracardinal vein, and the left supracardinal vein, then known as the hemiazygos vein, **empties into the azygos vein**

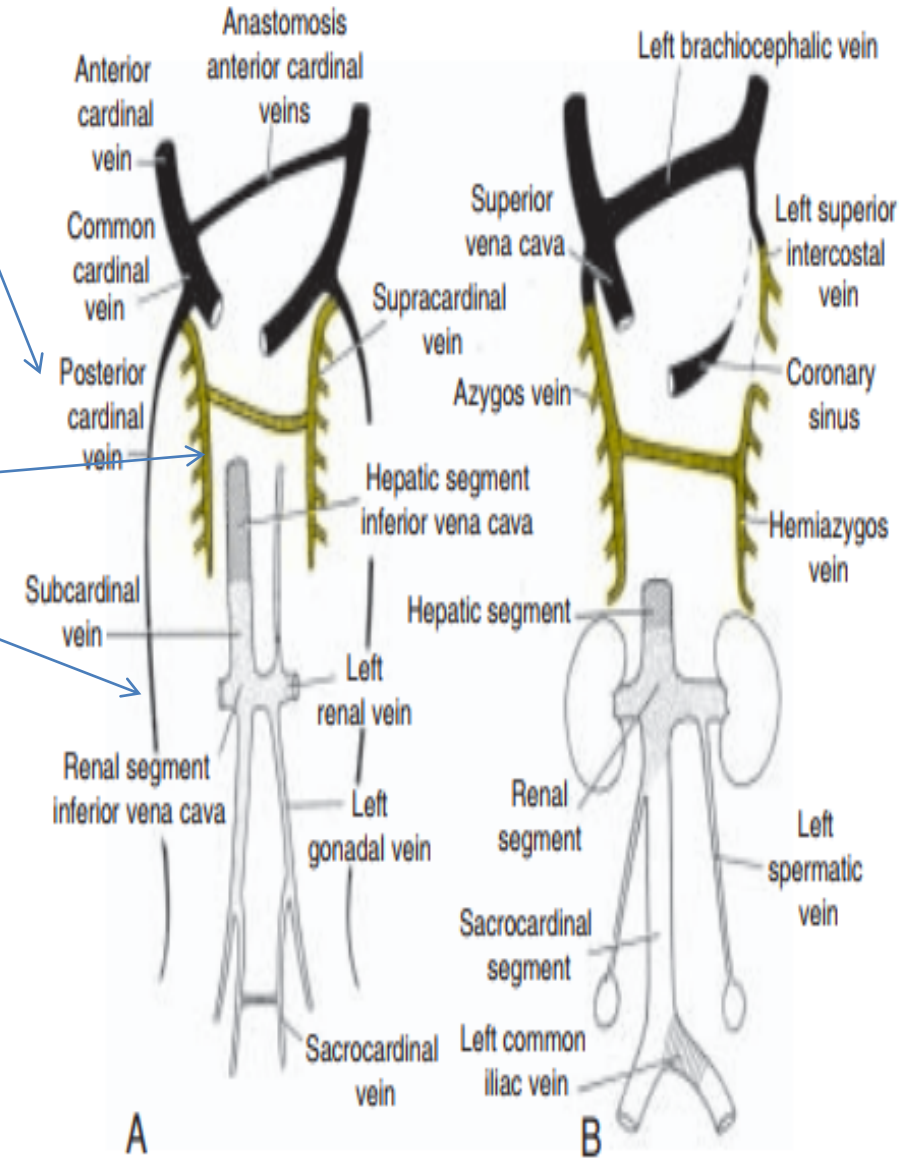
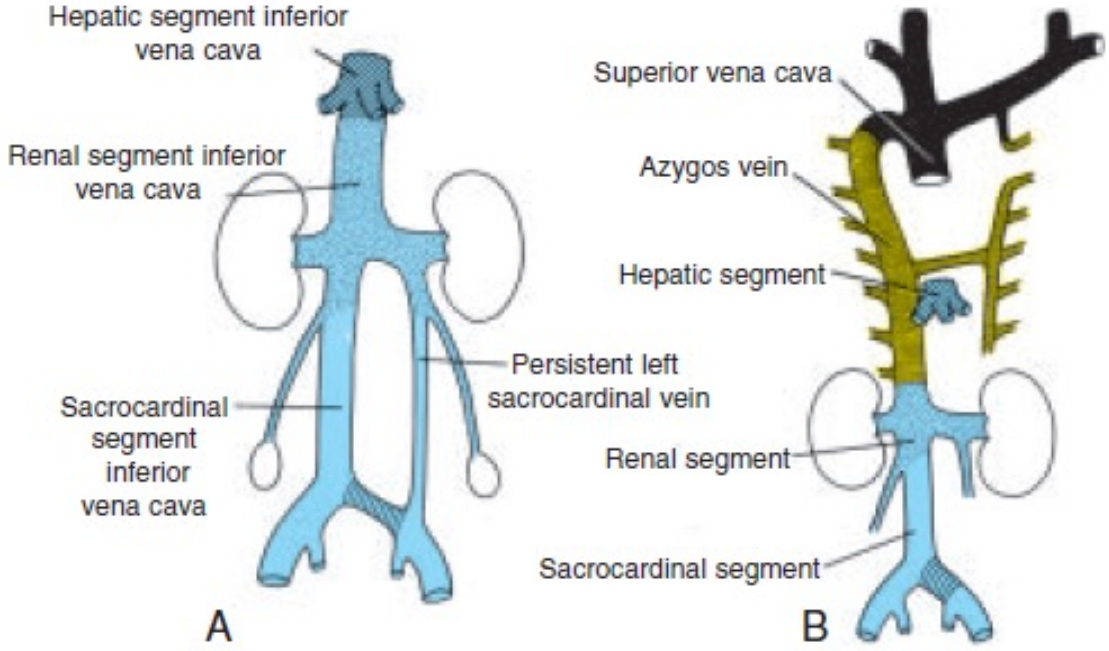


Figure 11.44 Development of the inferior vena cava, azygos vein, and superior vena cava. **A.** Seventh week. The anastomosis lies between the subcardinals, supracardinals, sacrocardinals, and anterior cardinals. **B.** The venous system at birth showing the three components of the inferior vena cava.

Clinical correlates

Double inferior vena cava: Left sacrocardinal vein remain connected to the left subcardinal vein

Absence of the inferior cava : The right subcardinal vein fails to make the connection with the liver



Read this paper

Double Inferior Vena Cava Detected by CT Venography and Confirmed by Magnetic Resonance Venography: Embryogenesis and Literature Review

Maher T. Hadidi ; Darwish H. Badran ; Jamal Abu Ghaida; **Amjad T. shatarat**; Azmy M. Al-Hadidy & Emad Tarawneh

Int. J. Morphol., 34(3):1087-1091, 2016.

AORTIC ARCH SYSTEM

The major arteries in an early embryo are represented by a pair of vessels

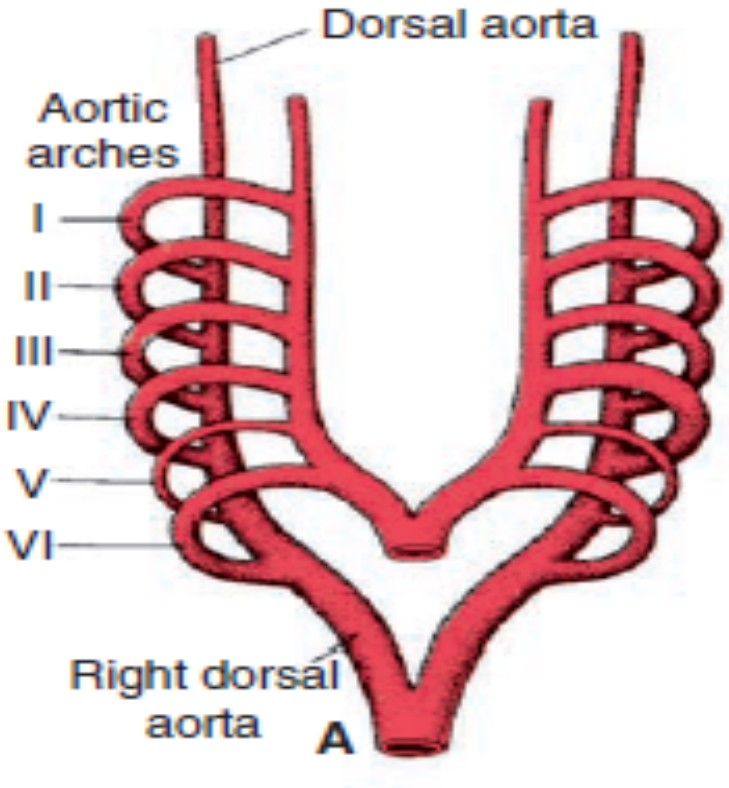
THE DORSAL AORTAE,

which run with the long axis of the embryo and form the continuation of the endocardial heart tubes.

The cranial portion of each dorsal aorta forms an arc on both sides of the foregut, thus establishing the first pair of aortic arch arteries, termed aortic arches

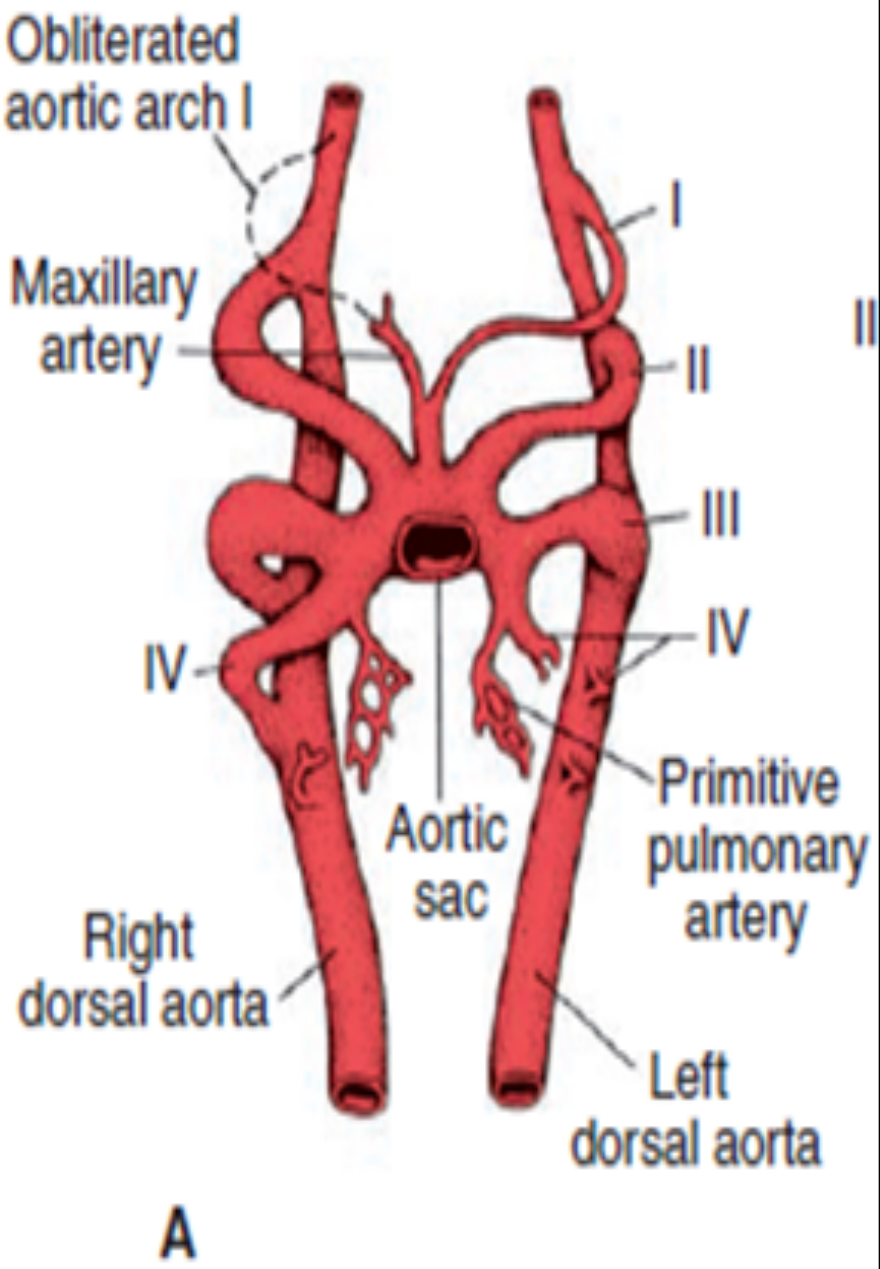
Arterial System

- *Aortic Arches*
- they run within branchial (pharyngeal) arches
- These arteries, the **aortic arches, arise from the aortic sac, the most distal** part of **the truncus arteriosus .**
- The aortic sac, giving rise to a total of five pairs of arteries.
- The pharyngeal arches and their vessels appear in a cranial-to-caudal sequence, so that they are not all present simultaneously.
- Consequently, the five arches are numbered I, II, III, IV, and VI .
- *During further development,* this arterial pattern becomes modified, and some vessels regress completely.



- Division of the **truncus arteriosus** by the **aorticopulmonary** septum divides the outflow channel of the heart into the **ventral aorta and the pulmonary trunk.**

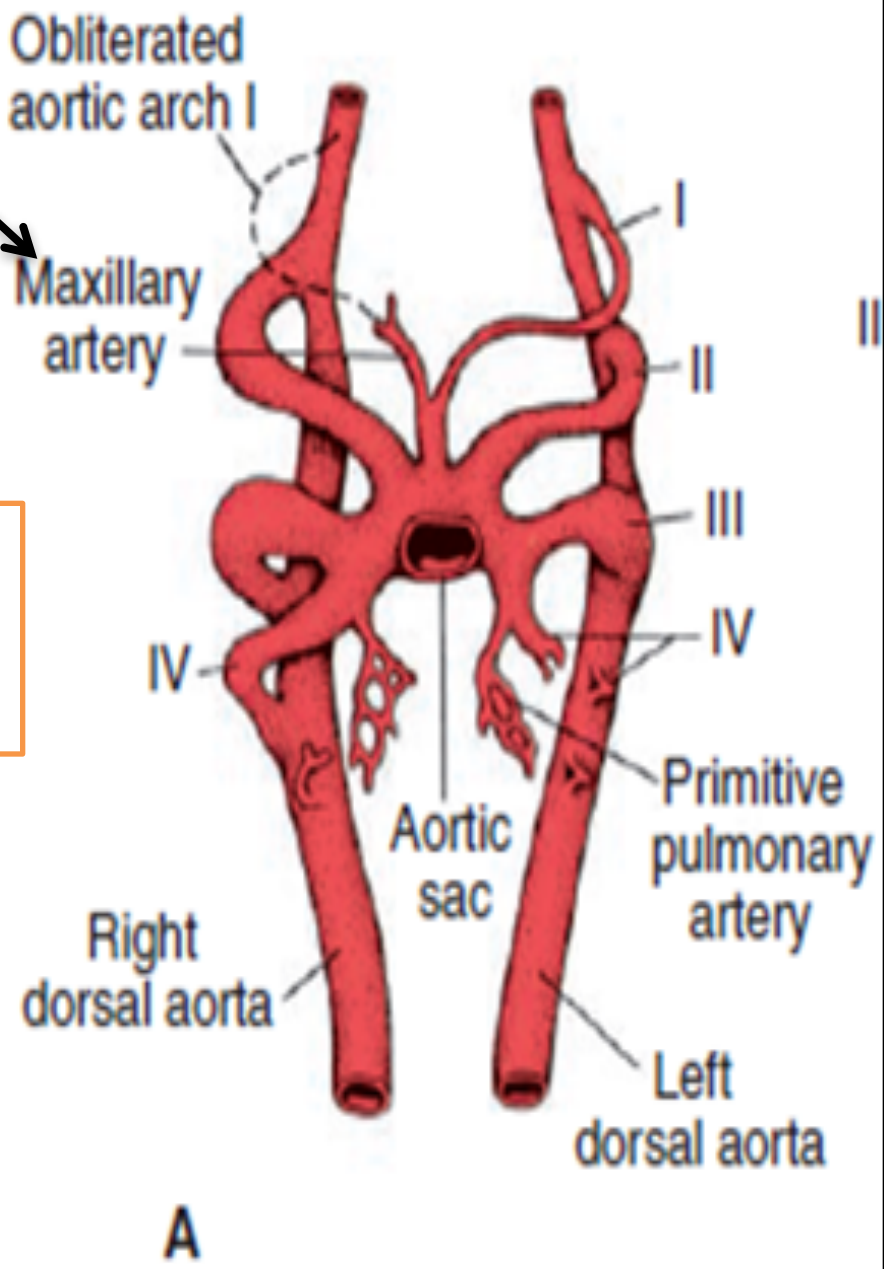
The aortic sac then forms right and left horns, which subsequently give rise to
the **brachiocephalic artery and the proximal segment of** the **aortic arch, respectively .**



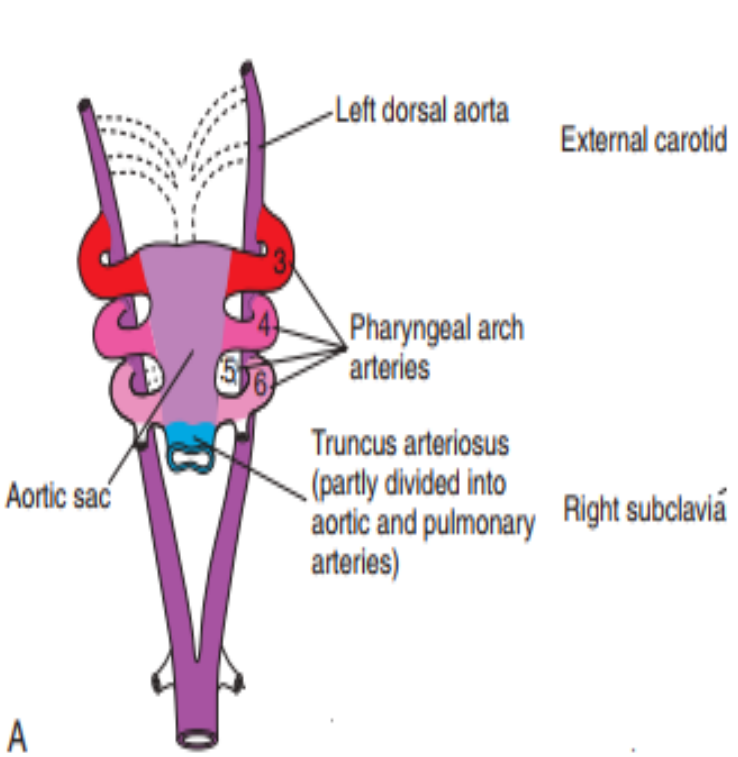
The first pair of arteries largely disappears but remnants of them form **part of the maxillary arteries,** which supply the ears, teeth, and muscles of the eyes and face

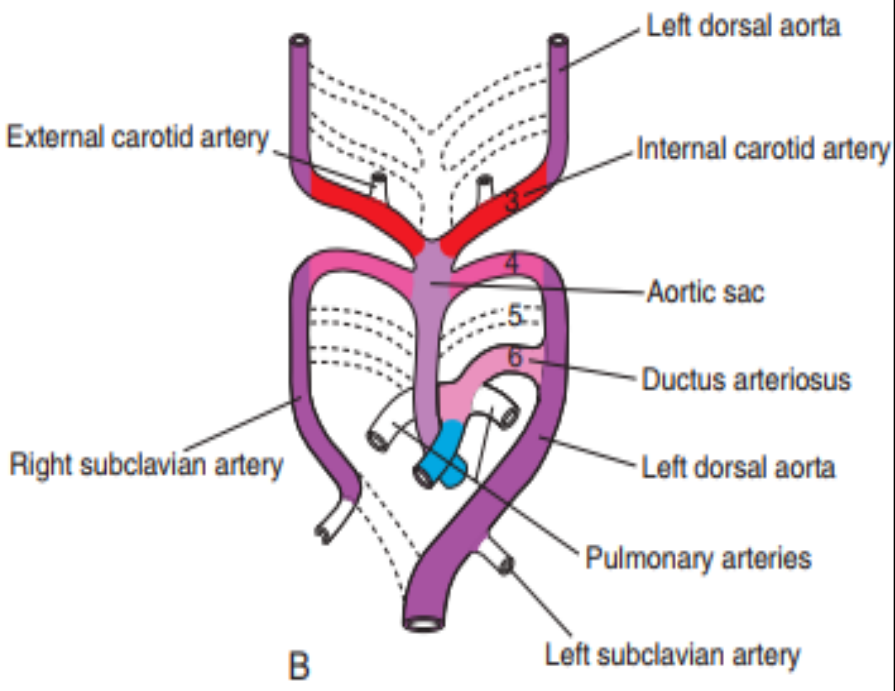
Derivatives of Second Pair of Pharyngeal Arch Arteries

Dorsal parts of these arteries persist and form the stems of **the small stapedial arteries**; these small vessels run through the ring of the stapes, a small bone in the middle ear



Derivatives of Third Pair of Pharyngeal Arch Arteries



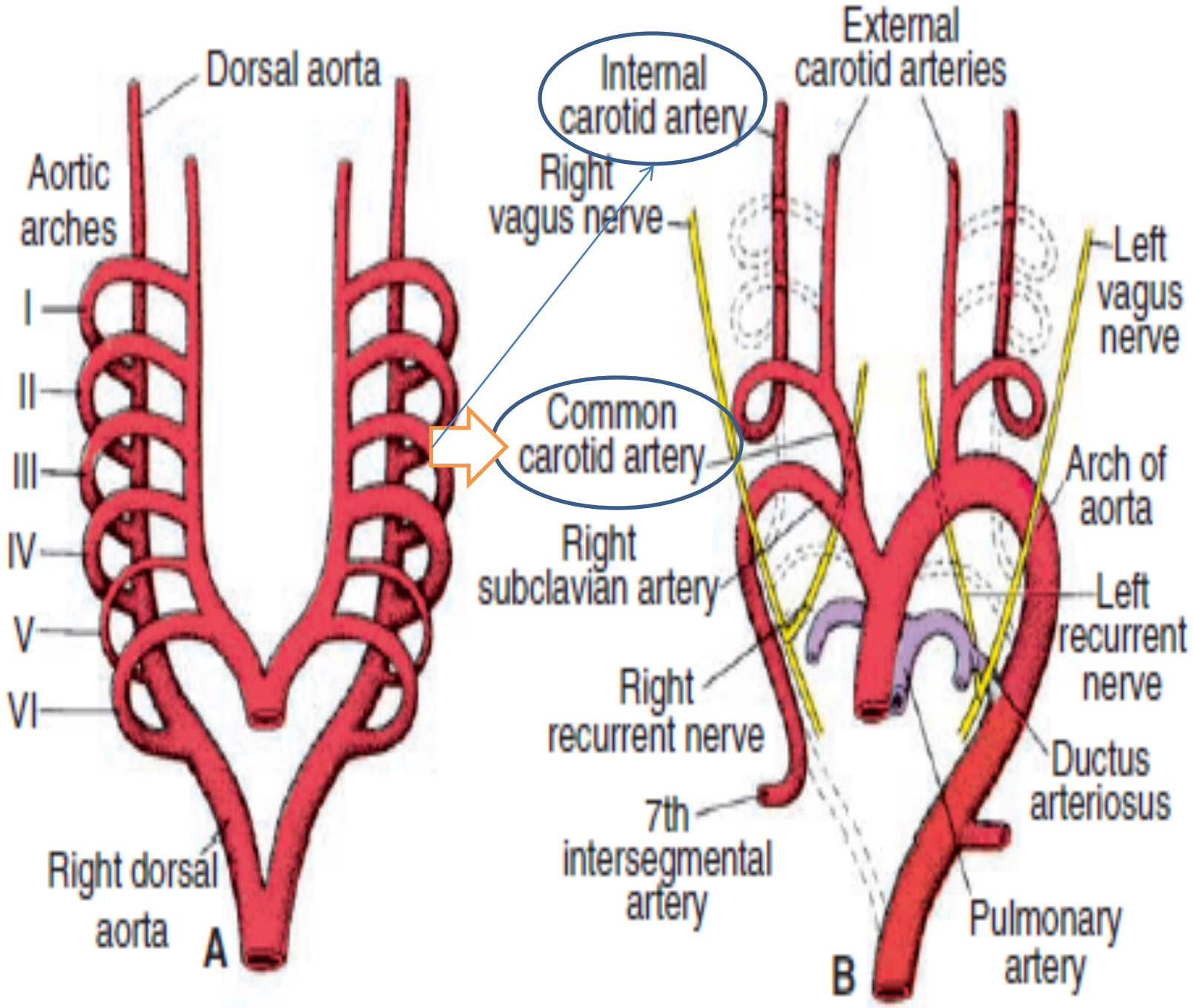


<u>Proximal parts</u> of these arteries form

THE COMMON CAROTID ARTERIES

<u>Distal parts</u> of these arteries join with **<u>the dorsal aortae</u>** to form

THE INTERNAL CAROTID ARTERIES

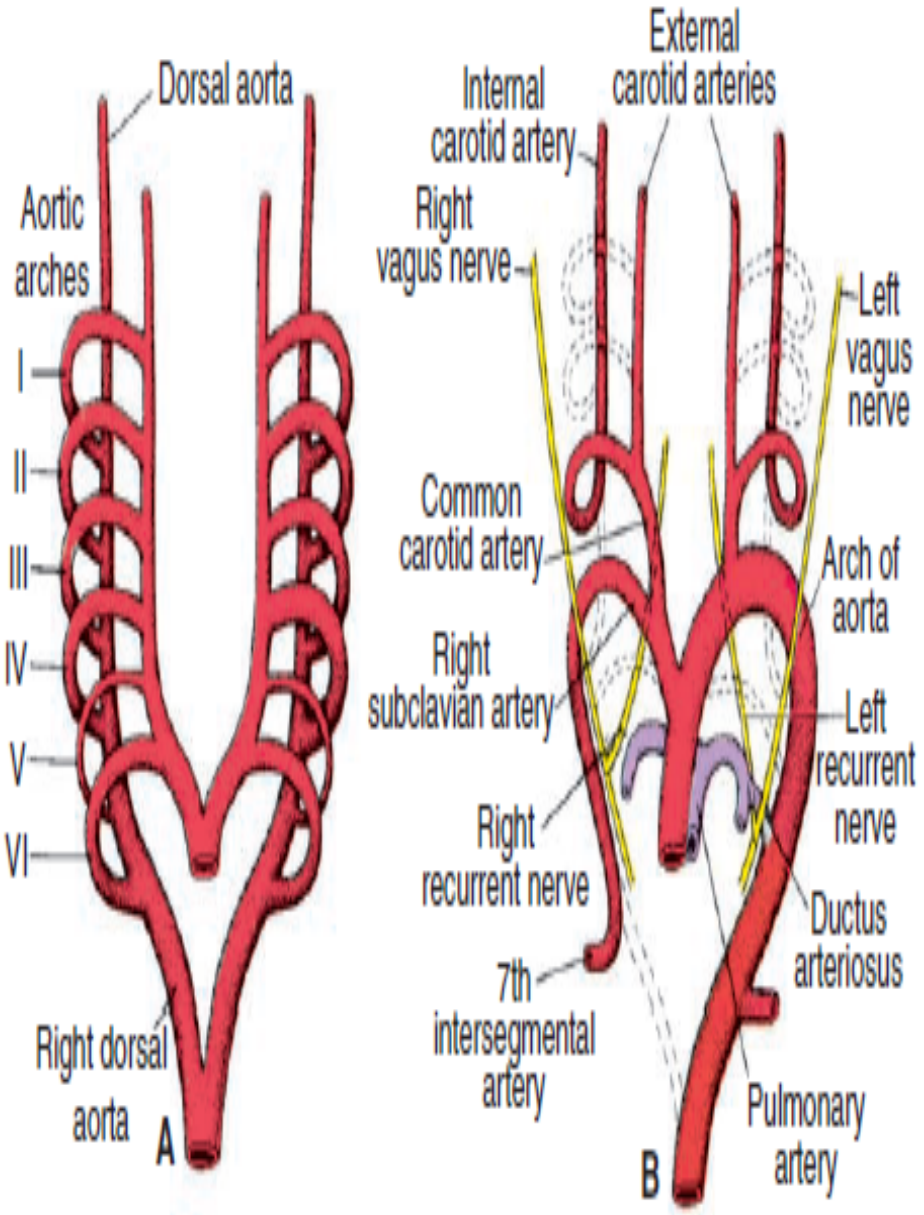

Dorsal aorta
Aortic arches
I
II
III
IV
V
VI
Right dorsal aorta
A
Internal carotid artery
External carotid arteries
Right vagus nerve
Left vagus nerve
Common carotid artery
Arch of aorta
Right subclavian artery
Left recurrent nerve
Right recurrent nerve
Ductus arteriosus
7th intersegmental artery
Pulmonary artery
B

Derivatives of Fourth Pair of Pharyngeal Arch

- The fourth aortic arch persists on both sides, but its ultimate fate is different on the right and left sides.

On the left, it forms **part of the arch of the aorta**, between the left common carotid and the left subclavian arteries.

On the right, it forms the most proximal segment of **the right subclavian artery**, the distal part of which is formed by a portion of the right dorsal aorta and the seventh intersegmental artery .

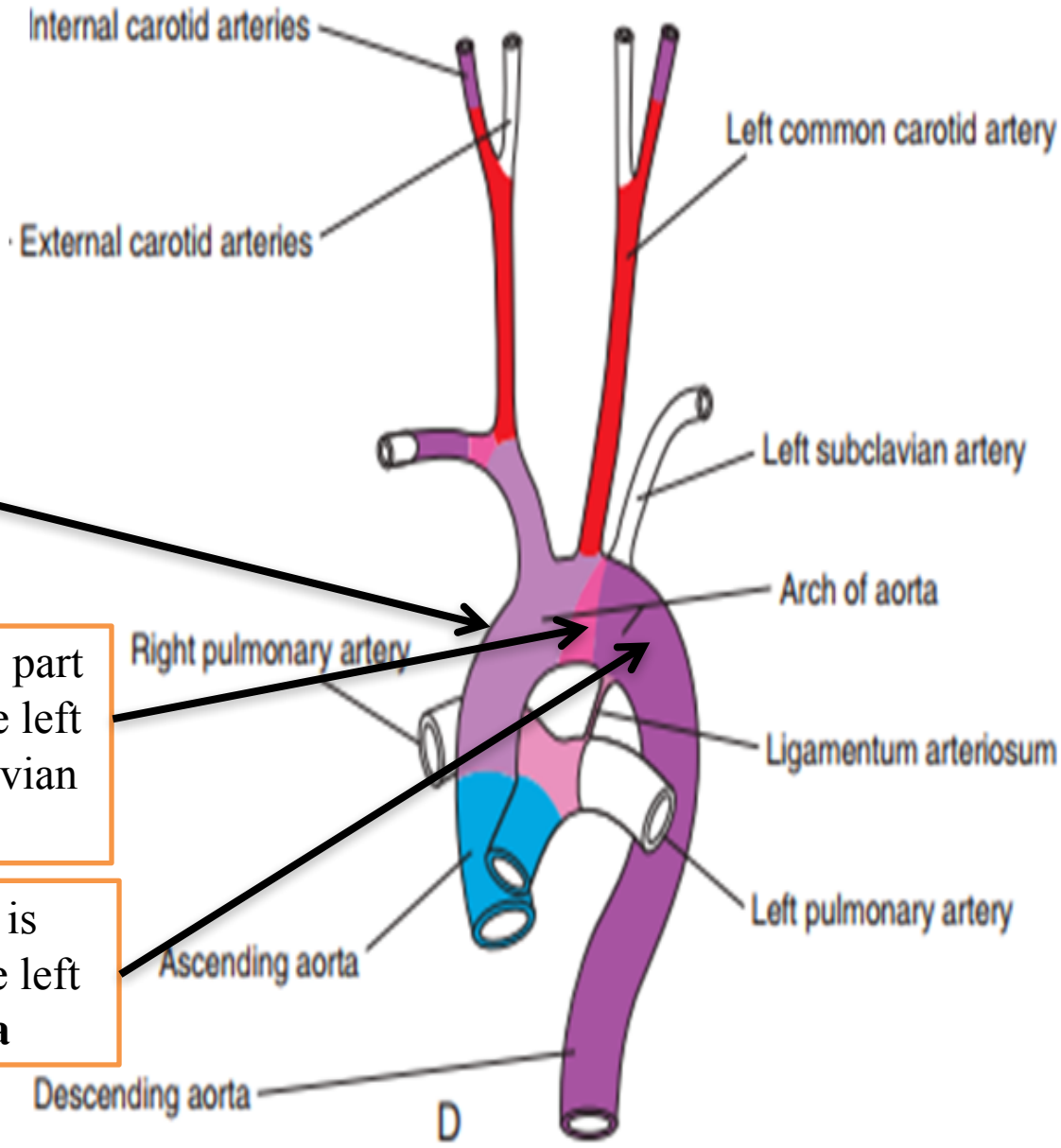


ARCH of the Aorta

1-The proximal part of the arch artery develops **from the aortic sac**

2- **left fourth aortic arch** , it forms part of the arch of the aorta, between the left common carotid and the left subclavian arteries.

the distal part is derived from the left **dorsal aorta**



The **fifth aortic arch either never forms or forms incompletely** and then **regresses**.

The **sixth aortic arch**

also known as the pulmonary arch, gives off an important branch that grows toward the developing lung bud .

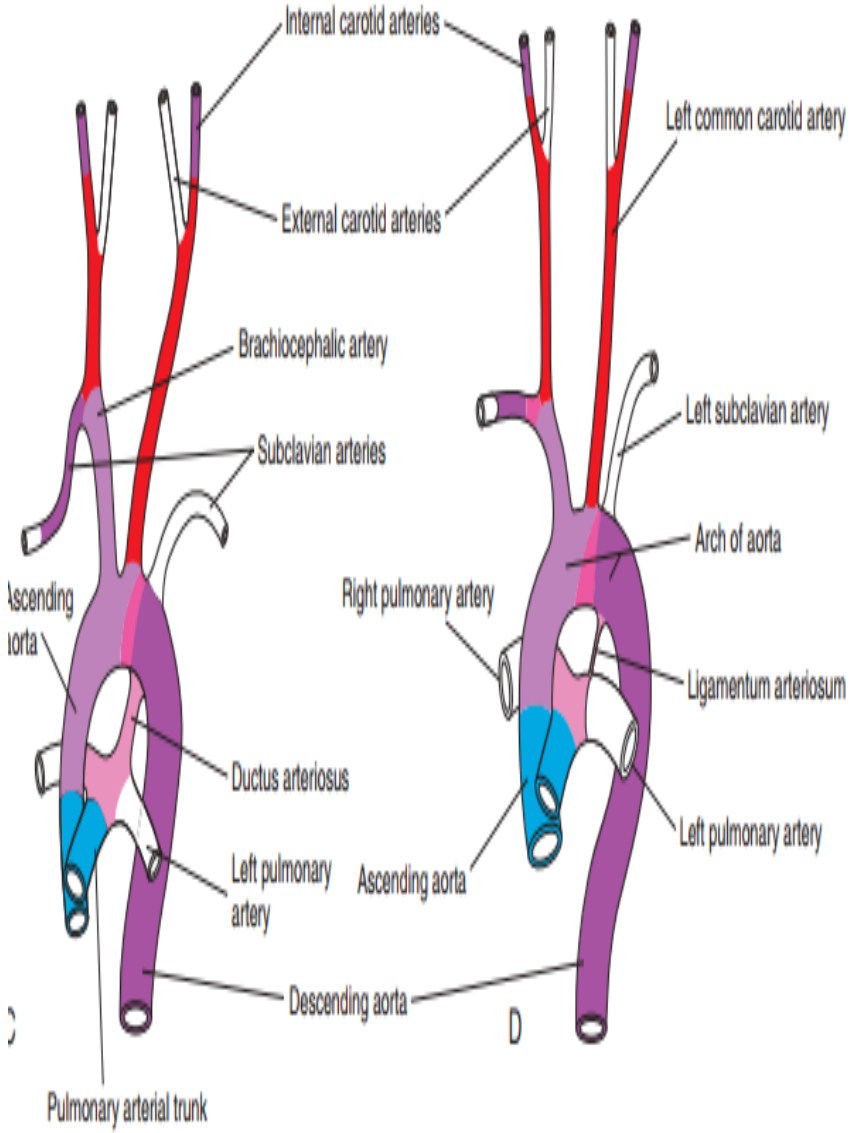
*On **the right side**, the **proximal*** **part** becomes the proximal segment of the **right pulmonary artery**.

The **distal portion** of this arch loses its connection with the dorsal aorta and **disappears**.

On **the left**, the distal part **persists** during intrauterine life as

THE DUCTUS ARTERIOSUS

The proximal part of the artery persists as the proximal part of the left pulmonary artery



Arch	Arterial Derivative
1	Maxillary arteries
2	Hyoid and stapedial arteries
3	Common carotid and first part of the internal carotid arteries[a]
4 Left side	Arch of the aorta from the left common carotid to the left subclavian arteries[b]
Right side	Right subclavian artery (proximal portion)[c]
6 Left side	Left pulmonary artery and ductus arteriosus
Right side	Right pulmonary artery

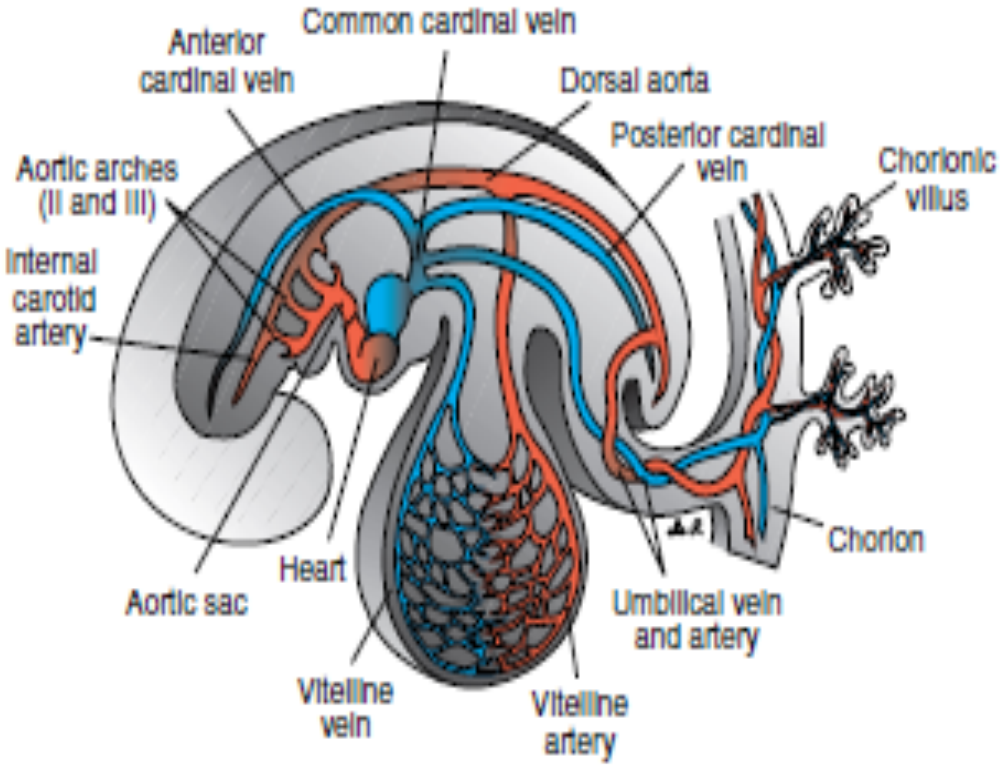
- The vitelline arteries, initially a number of paired vessels supplying the yolk sac

- gradually fuse and form the arteries in the dorsal mesentery of the gut

- In the adult, they are represented by the ***celiac and superior mesenteric, arteries***.

- The inferior mesenteric arteries are derived ***from the umbilical arteries***.

Vitelline and Umbilical Arteries



- These 3 vessels supply derivatives of

the foregut, midgut, and hindgut, respectively

The **umbilical arteries**

- The umbilical arteries, initially paired ventral branches of the dorsal aorta,
- course to the placenta in close association with the allantois .
- During the fourth week, each artery acquires a secondary connection with the dorsal branch of the aorta, the common iliac artery, and loses its earliest origin.

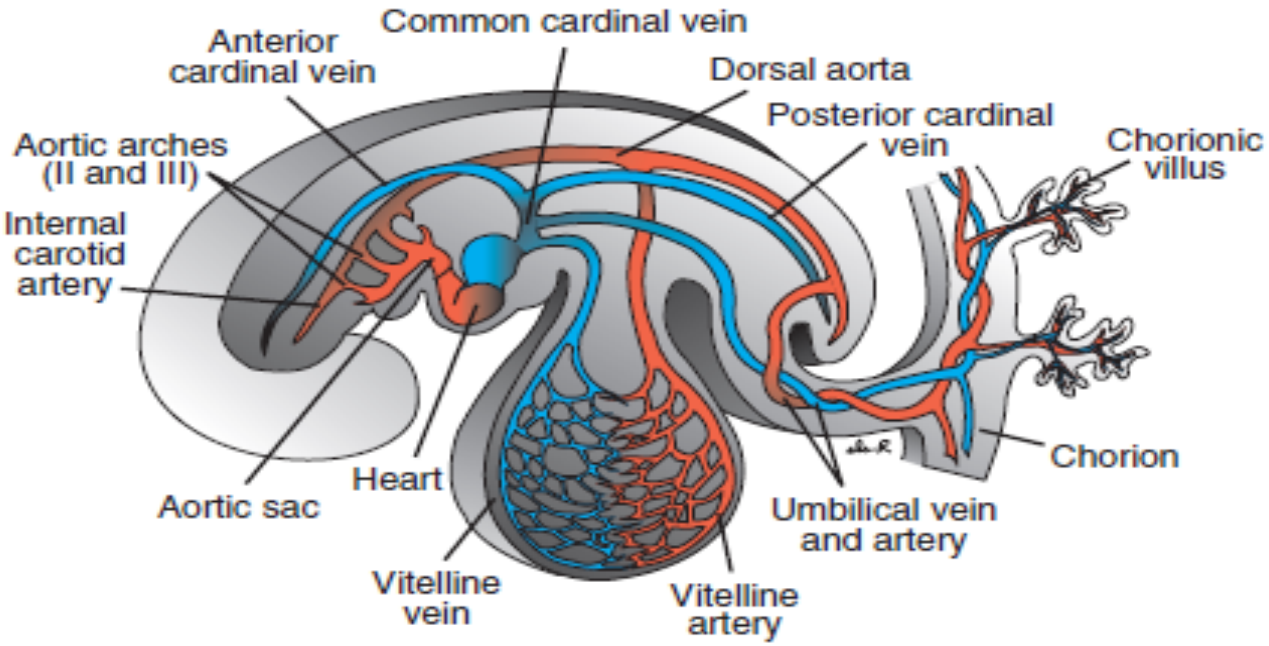


Figure 13.35 Main intraembryonic and extraembryonic arteries (*red*) and veins (*blue*) in a 4-mm embryo (end of the fourth week). Only the vessels on the left side of the embryo are shown.

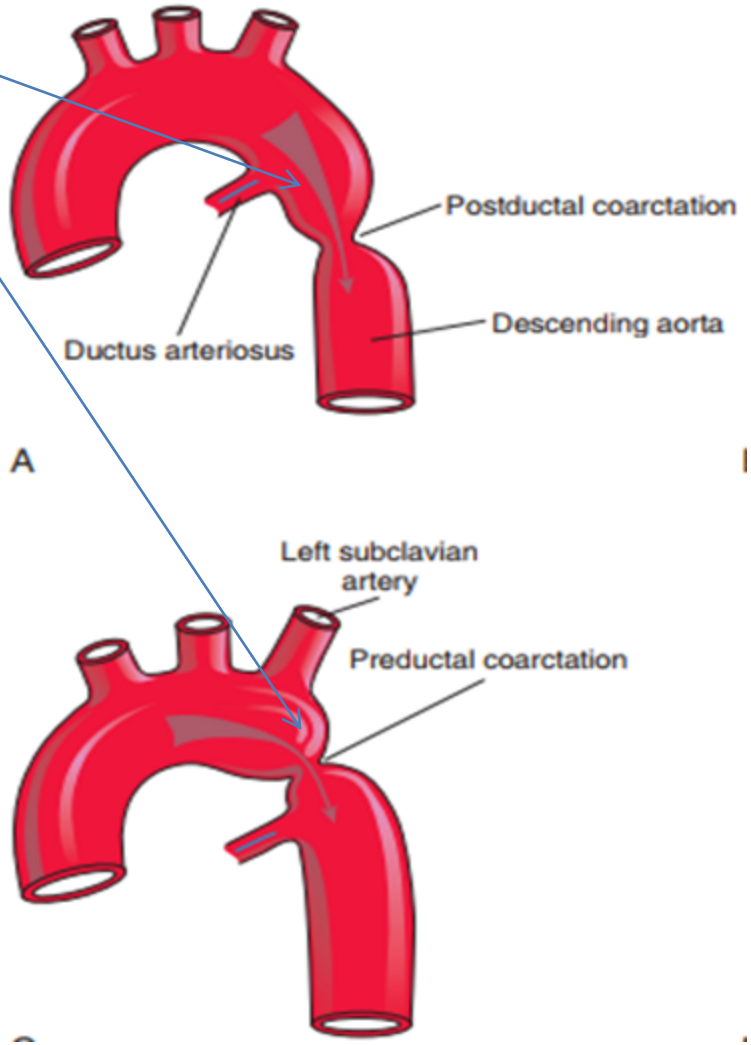
Coarctation of the aorta

- is a congenital narrowing of the aorta just ***proximal***, ***opposite,*** or ***distal*** to the **site of attachment of the ligamentum arteriosum**..

- However, most constrictions occur distal to the origin of the left subclavian artery, at the entrance of the DA **(juxtaductal coarctation).**

- occurs in approximately 10% of children with CHDs.

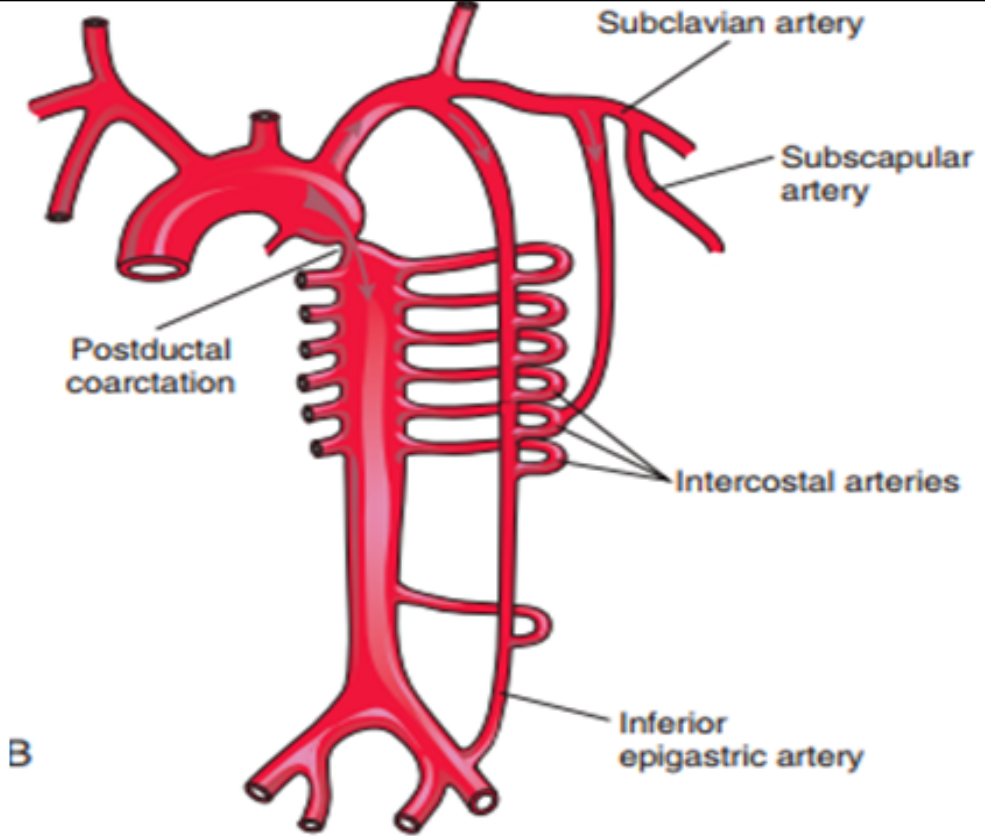
A classification system of preductal and postductal coarctations is commonly used; however, in 90% of cases, the coarctation is directly opposite the DA. Coarctation occurs two times as often in males as in females,

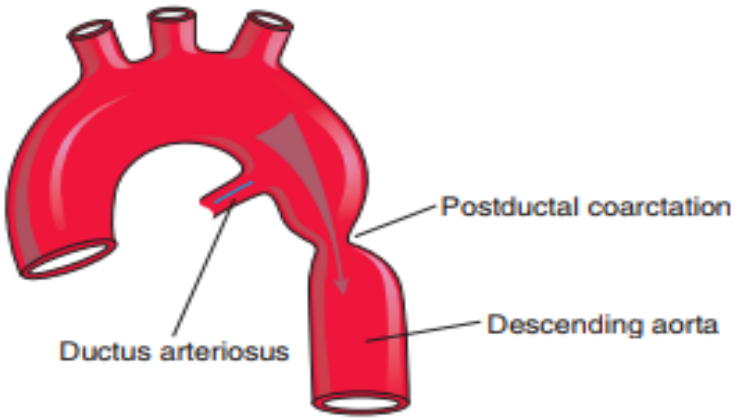


Cause: this condition is believed to result from an unusual quantity of ductus arteriosus muscle tissue in the wall of the aorta.
When the ductus arteriosus contracts, the ductal muscle in the aortic wall also contracts, and the aortic lumen becomes narrowed. Later, when fibrosis takes place, the aortic wall also is involved, and permanent narrowing occurs

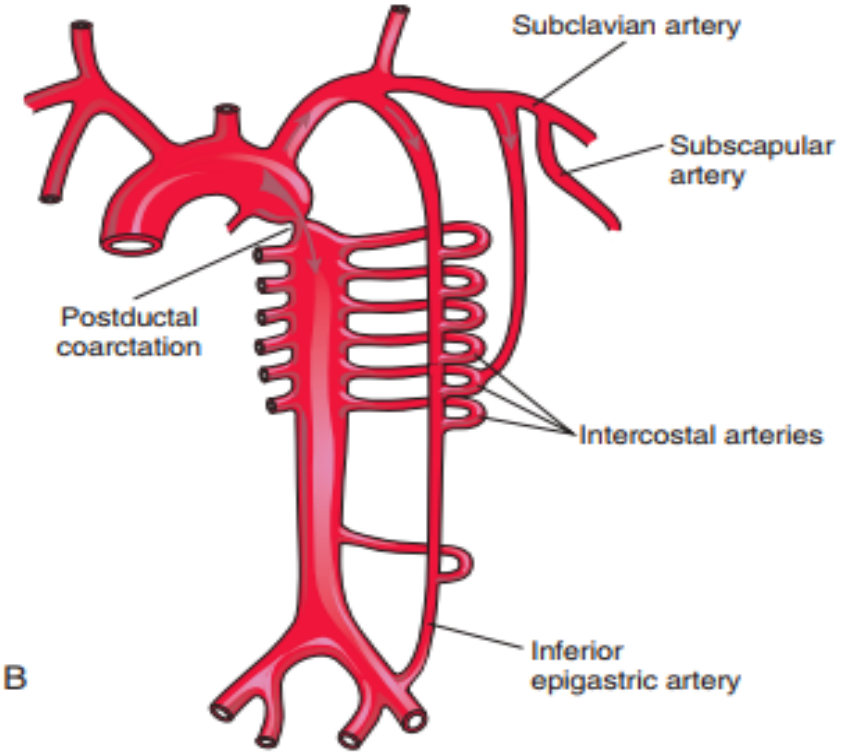
Clinically, the cardinal sign of aortic coarctation is **absent or diminished pulses in the femoral arteries of both lower limbs**.

To compensate for the diminished volume of blood reaching the lower part of the body, an enormous **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. The condition should be treated surgically





A



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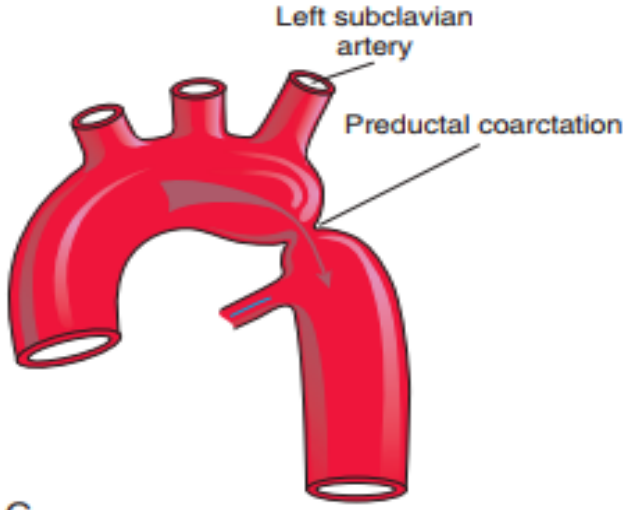


C

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.

Ductus Arteriosus and Ligamentum Arteriosum

- Functional closure of the DA is usually completed 10 to 15 hours after birth.
- Anatomical closure of the DA and formation of the ligamentum arteriosum usually occurs by the 12th postnatal week

Patent ductus arteriosus (PDA)

a common birth defect, occurs two to three times more frequently in females than in males
Functional closure of the PDA usually occurs soon after birth; however, if it remains patent (open), aortic blood is shunted into the pulmonary artery

PDA is the most common birth defect associated with **maternal rubella infection during early pregnancy**. **Preterm neonates** and those born at high altitude may have PDA; this patency is the result of hypoxia **(decrease of oxygen)** and immaturity.
The embryologic basis of PDA is failure of the DA to involute after birth and form the ligamentum arteriosum

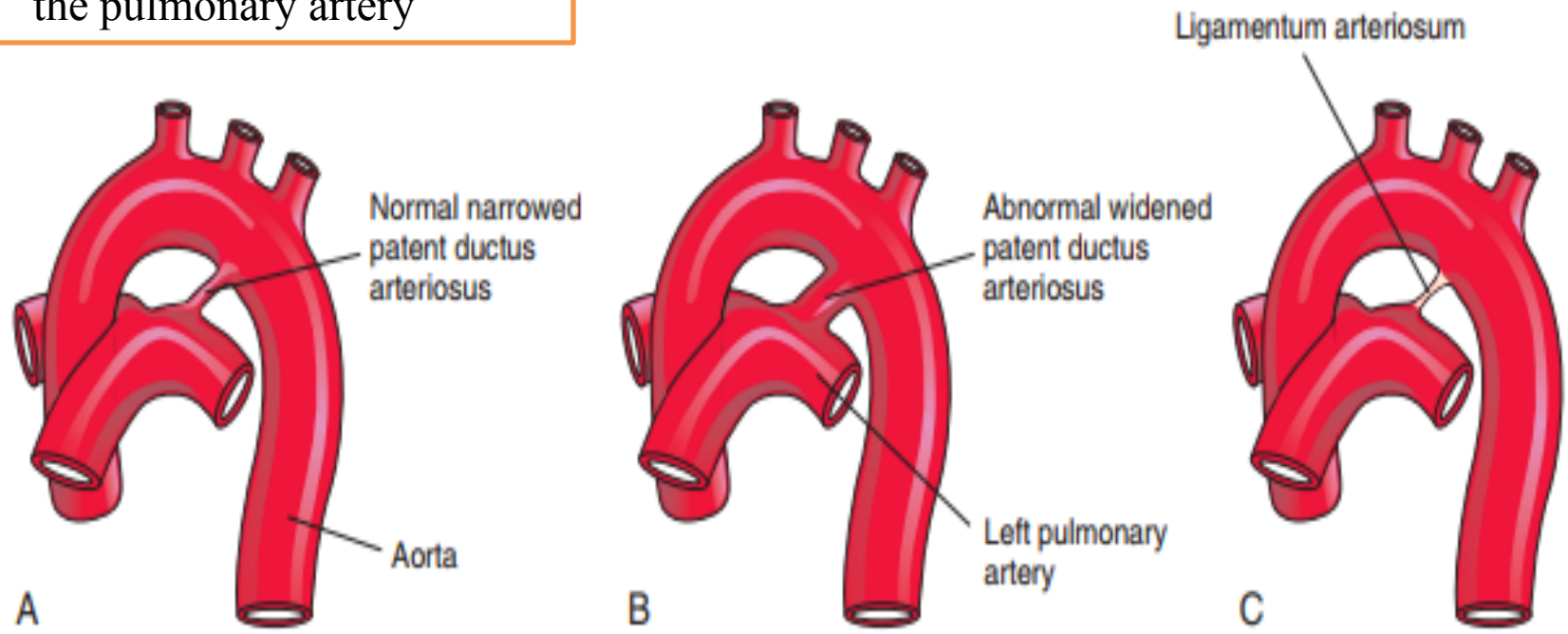


Figure 14–34 Closure of the ductus arteriosus (DA). **A,** The DA of a neonate. **B,** Abnormal patent DA in a 6-month-old infant. **C,** The ligamentum arteriosum in a 6-month-old infant.

FETAL CIRCULATION

Arterial systems associated with the fetal heart

During fetal circulation,

- oxygenated blood flood from the placenta to the fetus passes through ***the umbilical vein***.
- Three vascular shunts develop in the fetal circulation to bypass blood flow around the liver and lungs
- **The ductus venosus** allows oxygenated blood in the umbilical vein to bypass the sinusoids of the liver into the inferior vena cava and to the right atrium.
- From the right atrium, oxygenated blood flows mostly through the **foramen ovale** into the left atrium then left ventricle and into the systemic circulation.
- The foramen ovale develops during atrial septation to allow oxygenated blood to bypass the pulmonary circulation. Note that this is a right-toleft shunting of blood during fetal life.
- During fetal circulation, the superior vena cava drains deoxygenated blood from the upper limbs and head into the right atrium. Most of this blood flow is directed into the right ventricle and into the pulmonary trunk.
- **The ductus arteriosus** opens into the underside of the aorta just distal to the origin of the left subclavian artery and shunts this deoxygenated blood from the pulmonary trunk to the aorta to bypass the pulmonary circulation

fetal circulation

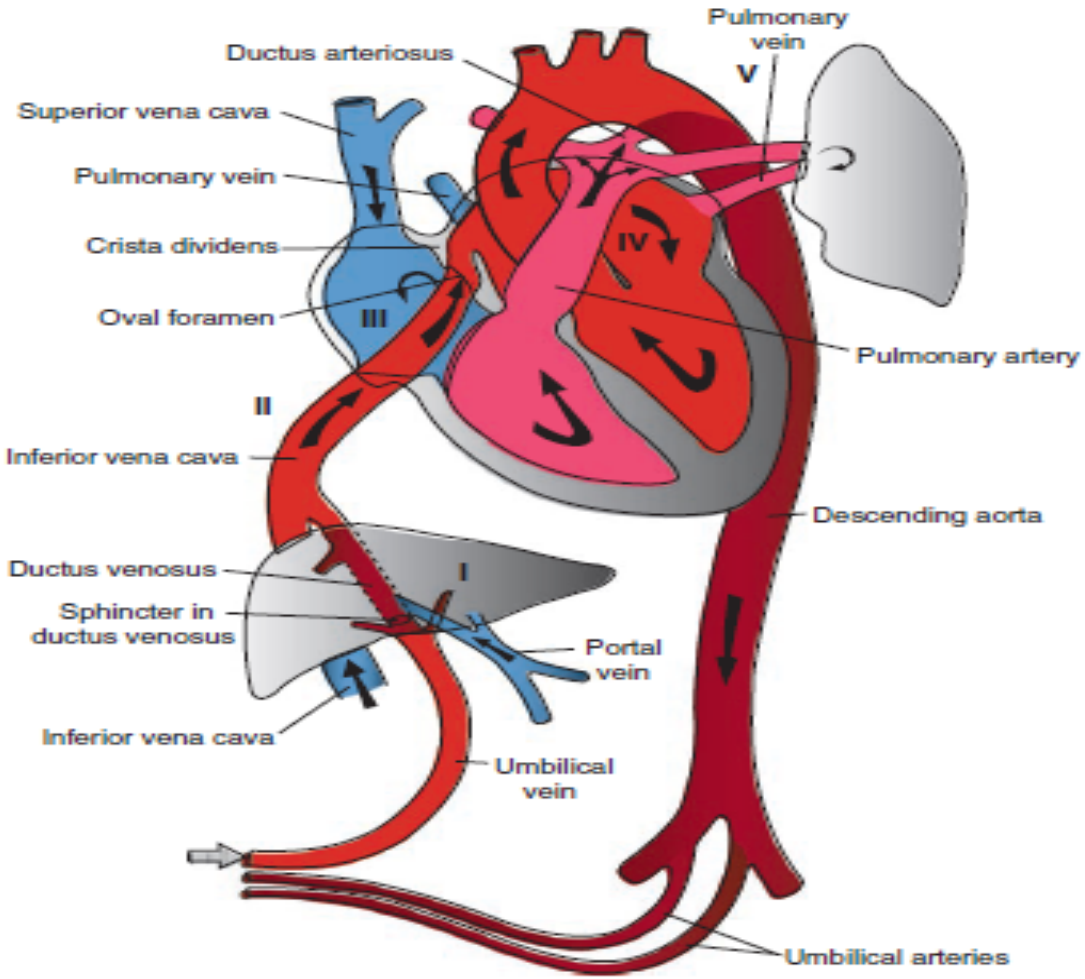


Figure 13.49 Fetal circulation before birth. *Arrows*, direction of blood flow. Note where oxygenated blood mixes with deoxygenated blood in: the liver (*I*), the inferior vena cava (*II*), the right atrium (*III*), the left atrium (*IV*), and at the entrance of the ductus arteriosus into the descending aorta (*V*).

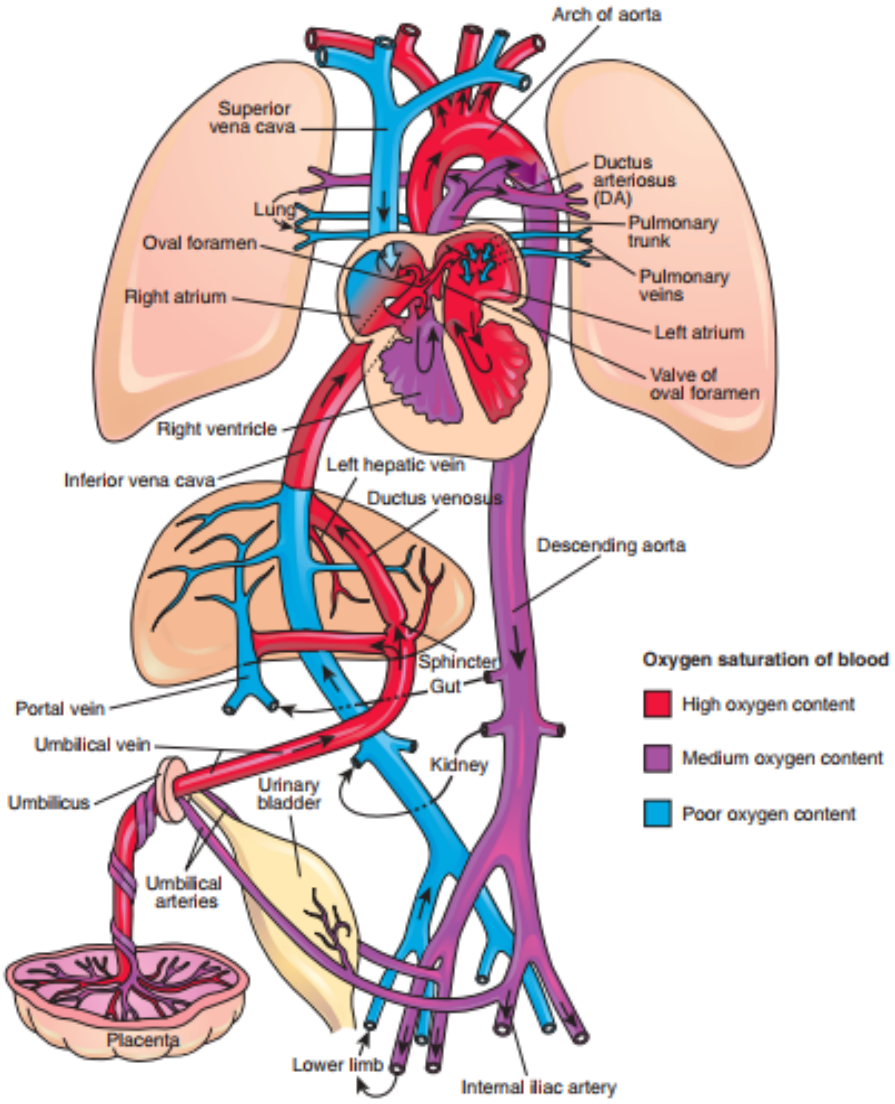
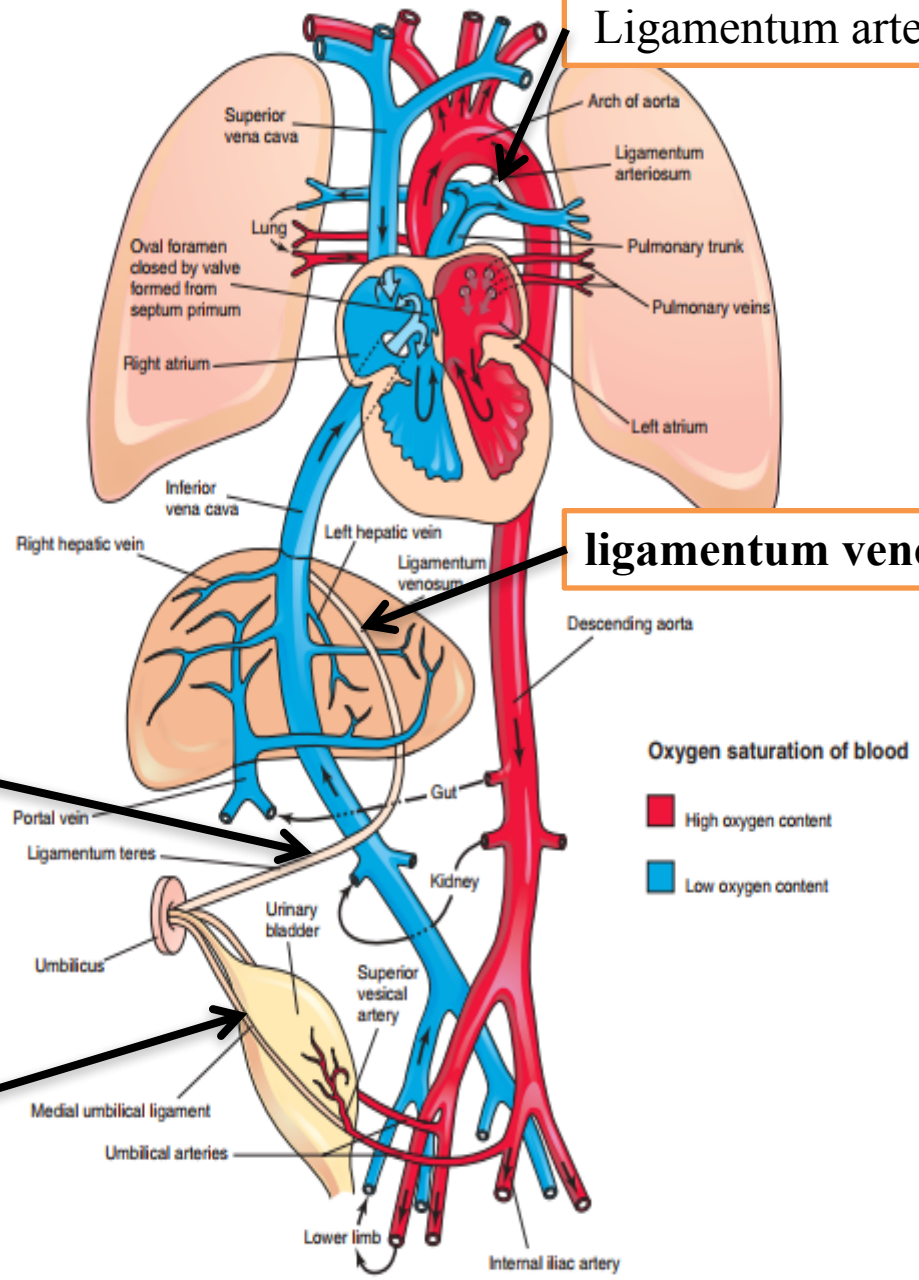


Figure 14–32 Fetal circulation. The colors indicate the oxygen saturation of the blood, and the arrows show the course of the blood from the placenta to the heart. The organs are not drawn to scale. A small amount of highly oxygenated blood from the inferior vena cava remains in the right atrium and mixes with poorly oxygenated blood from the superior vena cava. The medium-oxygenated blood then passes into the right ventricle. Observe that three shunts permit most of the blood to bypass the liver and lungs: (1) ductus venosus, (2) oval foramen, and (3) ductus arteriosus. The poorly oxygenated blood returns to the placenta for oxygen and nutrients through the umbilical arteries.

Circulatory Changes at Birth

- **During prenatal life, the** placental circulation provides the fetus with its oxygen, but after birth, the lungs take on gas exchange.
- In the circulatory system, the following changes take place at birth and in the first postnatal months:
- (1) the ductus arteriosus closes
- (2) the oval foramen closes
- (3) the umbilical vein and ductus venosus close and remain as the **ligamentum teres hepatis and ligamentum venosum**
- **(4) the umbilical arteries form** the **medial umbilical ligaments.**

Ligamentum arteriosum



ligamentum venosum

ligamentum teres hepatis

the umbilical arteries form the **medial umbilical ligaments.**

Figure 14–33 Neonatal circulation. The adult derivatives of the fetal vessels and structures that become nonfunctional at birth are shown. The arrows indicate the course of the blood in the infant. The organs are not drawn to scale. After birth, the three fetal shunts cease to function, and the pulmonary and systemic circulations become separated.

انتهى بحمد الله

The End
Thank you