

Embryology

L (1+2)

splanchnic part of lateral plate mesoderm

- The primitive ventricle is displaced ventrally and to the **left** of primitive atrium

Fate of the sinus venosus :

1) The left sinus horn: It diminishes in size due to:

- Left vitelline and left umbilical veins lose their connection with the left sinus venosus.

• Shift of the venous blood to the right side due to the development of transverse anastomoses

between the anterior cardinal veins and the posterior cardinal veins.

The left sinus horn becomes smaller and forms the coronary sinus.

2) The right sinus horn and central part of sinus venosus become absorbed into the right side

of the primitive common atrium and will form the sinus venarum (the posterior smooth part of right atrium).

• The right and left valves of the **sino-atrial orifice**:

• They fuse cranially to form the septum spurium .



• **Left** valve and septum spurium fuse with interatrial septum.

• **Right** valve:

• Its cranial part forms crista terminalis.

• Its caudal part forms the valves of I.V.C. and coronary sinus

Division of atrioventricular canal :

Ventral and dorsal endocardial cushions appear  fuse together  forming the **septum intermedium**

Development of the interatrial septum:

A. Septum primum :

The septum primum divides the cavity of the primitive atrium

incompletely into right and left halves because its caudal border is still separated from the endocardial cushions by gap called the **ostium primum**.

(The ostium primum becomes obliterated.)

A second foramen called **ostium secundum** appears as a result of breaking down of the cephalic part of the septum primum.

B.Septum Secundum : The septum secundum overlaps the ostium secundum but its caudal edge is still separated from the cephalic edge of septum primum by a gap called **foramen ovale**.

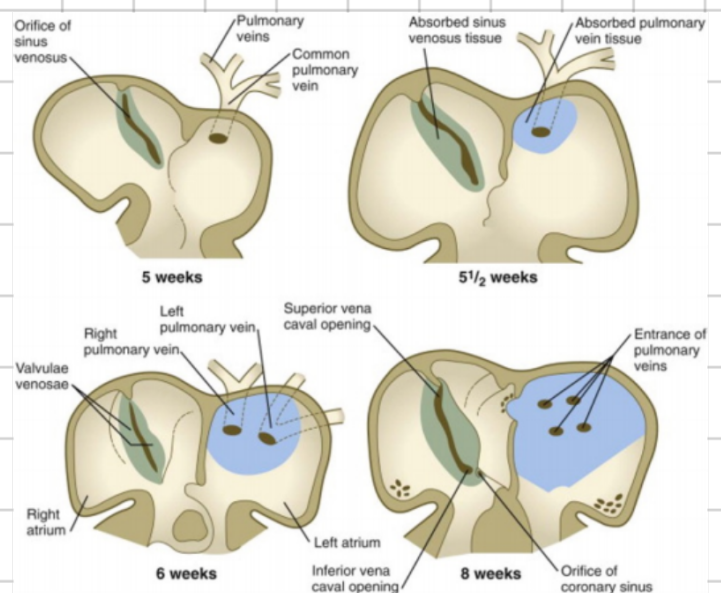
(Close at birth)

"The edge of the septum primum that forms the lower boundary of the foramen secundum is thin and mobile like a flap "

interatrial septum which is formed of : Septum primum ,Septum secundum,The free caudal edge.

Embryological components of each atrium

Components of the right atrium	Components of the left atrium
(1) The right 1/2 of the common primitive atrium (forms the anterior rough part + Right auricle).	(1) The left 1/2 of the common primitive atrium (forms the left auricle).
(2) The absorbed central part & right horn of sinus venosus (forms the posterior smooth part).	(2) The absorbed pulmonary vein and its tributaries (forms the posterior smooth part).
(3) The absorbed right atrioventricular canal	(3) The absorbed left atrioventricular canal



Anomalies of the interatrial septum :

1- Premature closure of foramen ovale: hypertrophy of right atrium and right ventricle with underdevelopment of left atrium & left ventricle. It leads to the death

2- **Atrial Septal Defects Atrial septal defect (ASD)** : more common in **female** than in male /left -to-right shunting /**non-cyanotic** conditions/ clinical symptoms may be delayed as late as **age 30** /**Secundum-type ASD** is the most common ASD It is caused by either an excessive resorption of the Septum primum or an underdevelopment and reduced size of the Septum Secundum or both.

3- Patent foramen ovale

4- Complete failure of formation of the interatrial septum: failure of separation of the 2 atria. /3 chambers (common atrium and 2 ventricles).

Anomalies of the atrio-ventricular canal :

1- Persistent A-V canal: complete failure of fusion of the ventral and dorsal endocardial cushions

2- Tricuspid atresia : fusion of the cusps of the tricuspid valve leading to its narrowing.

usually accompanied by patent foramen ovale, hypertrophy of left ventricle,

patent interventricular foramen and underdevelopment of right ventricle.

Development of the ventricles:

Formation of common bulboventricular chamber :

bulbus cordis moves to the left to lie in front of the common ventricle / The proximal part of the bulbus cordis becomes absorbed inside the primitive ventricle to form the common bulboventricular chamber./A ridges developed in the lumen of the bulbus cordis after their fusion are called bulbar septum

This septum is divided into ; the **Distal** bulbar septum and the **proximal** bulbar septum

1. **proximal** : closing interventricular foramen (Membranous part) /form smooth outflow parts Infundibulum (conus arteriosus) on the right

ventricle OR aortic vestibule of the left ventricle

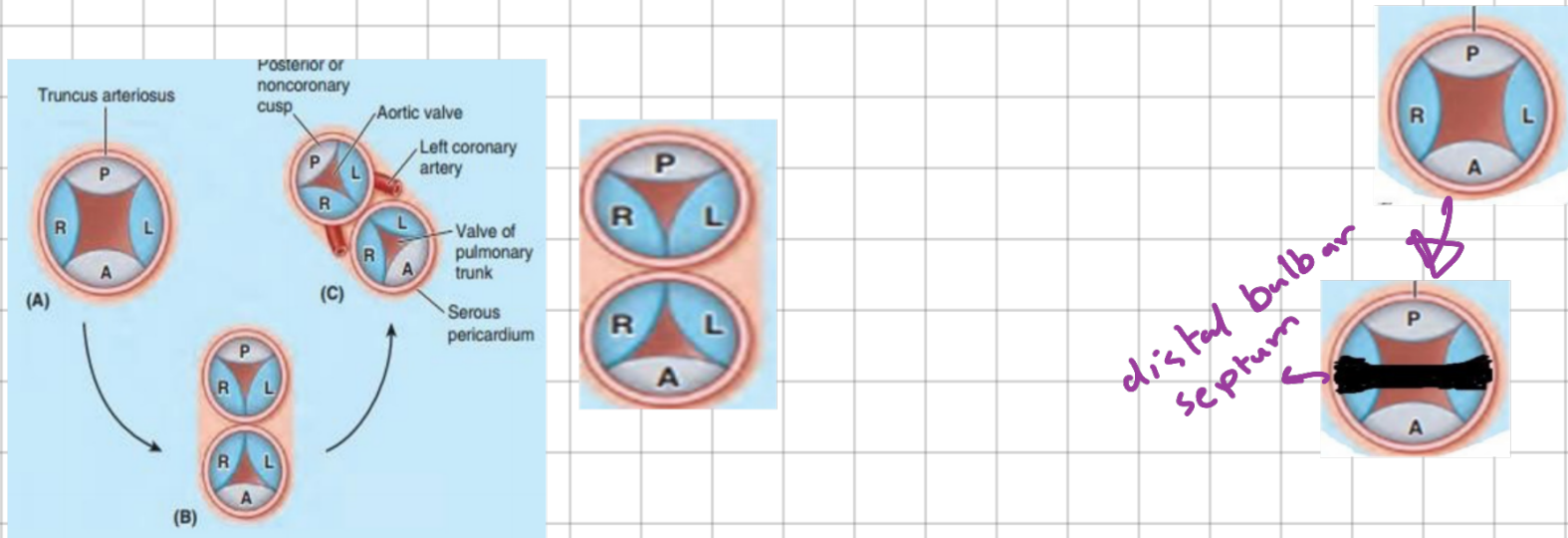
2. distal : Four endocardial cushions (ant, post, rt, lt) / form distal bulbar septum.

distal bulbar septum will divide the cranial end of bulbus cordis

: pulmonary orifice anteriorly and The aortic orifice posteriorly

- The cusps of the pulmonary valve → one anterior, right and left cusps

- The cusps of the aortic valve → one anterior posterior right and left cusps



interventricular (IV) septum :

#muscular part : from the floor of the bulboventricular / from the floor of the bulboventricular / interventricular foramen between the free edge of the interventricular septum and the septum intermedium.

#membranous part : close the interventricular foramen. /

It is developed from **3 structures** surrounding the interventricular foramen : The muscular ventricular septum / Atrio-ventricular endocardial cushion. / Right and left bulbar ridges.

Absorption of the proximal portion of bulbus cordis (conus cordis)

forming the outflow tracts of the both ventricles:

Right ventricle → infundibulum of pulmonary trunk .

left ventricle → vestibule of the aorta.

SOURCES OF THE VENTRICLES : 1. Primitive ventricle: Trabeculated part of (rt + lt) / 2. Bulbus cordis: outflow tracts of both ventricles
Infundibulum (conus arteriosus) on the right ventricle OR aortic vestibule of the left ventricle

Anomalies of the interventricular septum :

Ventricular septal defect : More common in **males** than in females/A defect may occur in the membranous as well as the muscular part of the IV septum./whole IV septum may be absent. /left-to-right shunting of blood through the IV foramen. /**noncyanotic**,/👉 causes increased blood flow and pressure to the lungs (pulmonary hypertension). 👉 pulmonary resistance becomes higher than systemic resistance and causes 👉 right-to-left shunting (**cyanosis**.) ⚠️➡️ At this stage, the condition is called **Eisenmenger complex** ⚠️

Embryology

L3

1) 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.

2) aortico-pulmonary septum: the pulmonary trunk lies anterior then to the left and finally posterior to the aorta

* The vessels of the embryo is developed from

Aortic Sac

Aortic arches

Dorsal + Common aorta

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.

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 <u>stapedial artery</u> .	
3rd	Forms the <u>Common Carotid Artery</u> and proximal part of the <u>Internal Carotid Artery</u> . External carotid is developed from a bud from CCA	
4th	Forms the proximal part of the <u>right subclavian artery</u> .	Forms the <u>middle part of the arch of aorta</u> .
5th	Disappears completely	
6th Ventral	Forms the <u>right pulmonary artery</u> .	Forms the <u>left pulmonary artery</u> .
6th Dorsal	Disappears.	Persists forming the <u>ductus arteriosus</u> , which forms a connection between the left pulmonary artery and arch of aorta.

Development of the arch of aorta

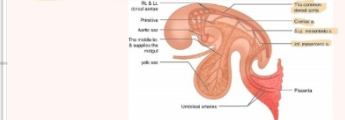
- The arch of aorta is developed from:
 - Its proximal part:** arises from the left horn of aortic sac.
 - Its middle part:** arises from the left 4th aortic arch.
 - Its distal part:** arises from the lower part of the left dorsal aorta to the level of 7th inter-segmental artery.
- N.B.:** The difference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

Fate of dorsal aorta: **DORSAL AORTA**

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

1) Branches from common dorsal aorta:

- Ventral splanchnic arteries:**
 - Coeliac artery: the most cranial and supplies the foregut.
 - Superior mesenteric artery: the middle and supplies the midgut.
 - Inferior mesenteric artery: the most caudal and supplies the hindgut.



2- Lateral splanchnic arteries:

- Diaphragmatic arteries:
- Middle suprarenal arteries:
- Renal arteries:
- Gonadal arteries.

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

1

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

X-ray image showing the boot-shaped heart.

Lineage ©

Handwritten note: **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 **severe 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**

2

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.

3

Congenital Anomalies of Arteries

1) Coarctation of the aorta :

- Is **narrowing of the aorta** either 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, **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 **rib 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 the closure** results in **shunt between arch of aorta and left pulmonary artery**.

Figure 16.29 A, Normal anatomy of the aorta. B, Coarctation of the aorta. C, Patent ductus arteriosus. Rib notching seen at chest. D, Patent ductus arteriosus. Shunt between arch of aorta and left pulmonary artery.

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.

Embryo

L4

DEVELOPMENT OF VEINS

Vitelline vein

Umbilical (oxygenated) blood

Cardinal

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

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**

Anterior Cardinal

Common Cardinal

Posterior Cardinal

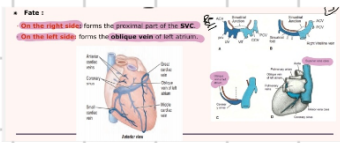
Supra-Cardinal

Sub Cardinal

Sacro-Cardinal

Fate:

- On the right side: it forms:
 - ① Right internal jugular vein,
 - ② Right brachiocephalic vein,
 - ③ Distal part of superior vena cava.
- On the left side: it forms:
 - ④ Left internal jugular vein,
 - ⑤ Proximal part of the left superior intercostal vein.
- The transverse connection forms the left brachiocephalic vein.



Fate:

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

Fate:

- On the right side: forms renal part of IVC.
- On the left side: forms the left gonadal vein.
- The intersubcardinal anastomosis forms left renal vein.

Fate:

- On the right side: most of it degenerates.
- On the left side: form the superior and inferior hemiazygos veins.
- The 2 transverse anastomoses form the connection between the brachiocephalic veins and the supra-cardinal veins.

The right sacrocardinal vein becomes the subcardinal segment of the inferior vena cava. The anastomosis between the sacrocardinal veins forms the left common iliac vein.

Development of inferior vena cava :

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

Changes in the circulation after birth : (age)

- 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 ligament

FETAL CIRCULATION :

FETAL CIRCULATION

(5)

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.**

nyin

II) The deoxygenated blood:

(5)

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 .