LOs:

- ❑ Define + explain principle embryological development of heart
- ❑ Describe foetal circulation pathway in-utero and how this changes after birth
- ❑ Define what is meant by a patent foramen ovale
- ❑ Describe and illustrate importance in Biochemistry of closure of ductus arteriosus

Cardiovascular System Embryology

Development of Heart

☆ Formation of heart begins at 3 Weeks – 18 days

☆ First Heartbeat heard at 4 Weeks – 22 days. (Blood forms later)

☆ Heart develops from **mesoderm**

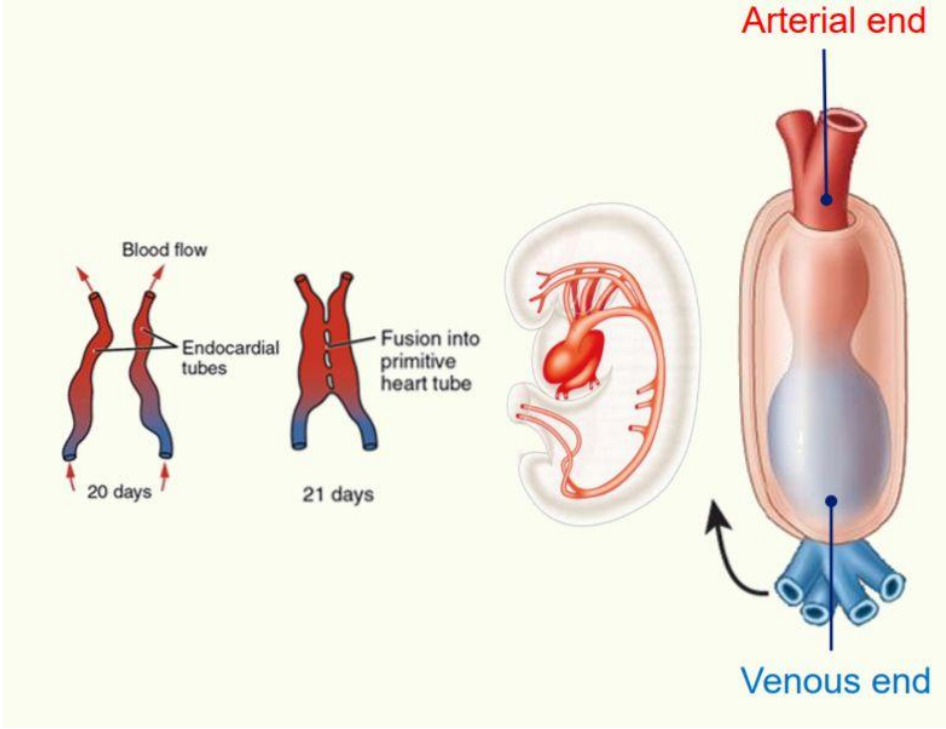
<u>HEART DEVELOPMENT:</u>

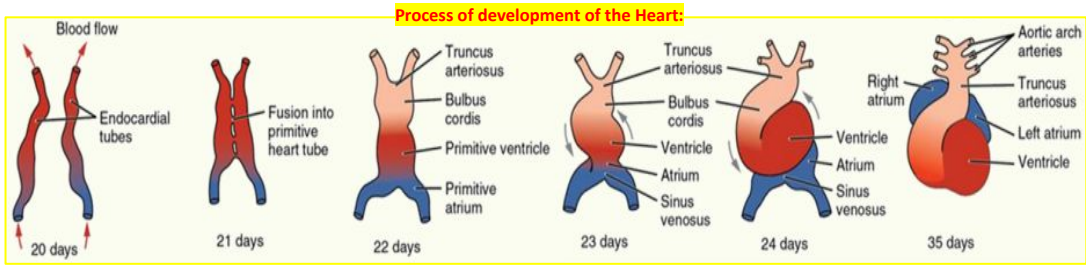
✿ **Endocardial tubes** form on each side of embryo

✿ **Folding** of embryo brings them together → fuses into a **single heart tube**

✿ Heart tube folds and **partitions** to create a **four-chambered structure**

*AV valves derived from the endocardial cushions

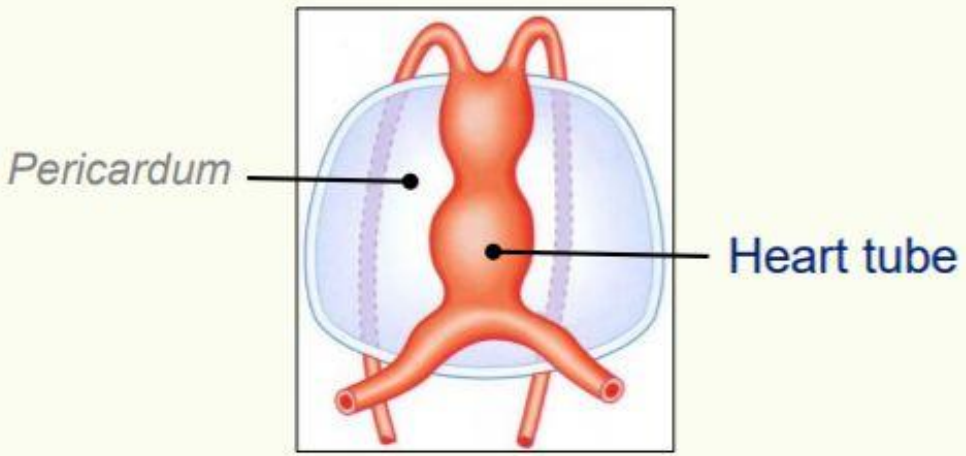


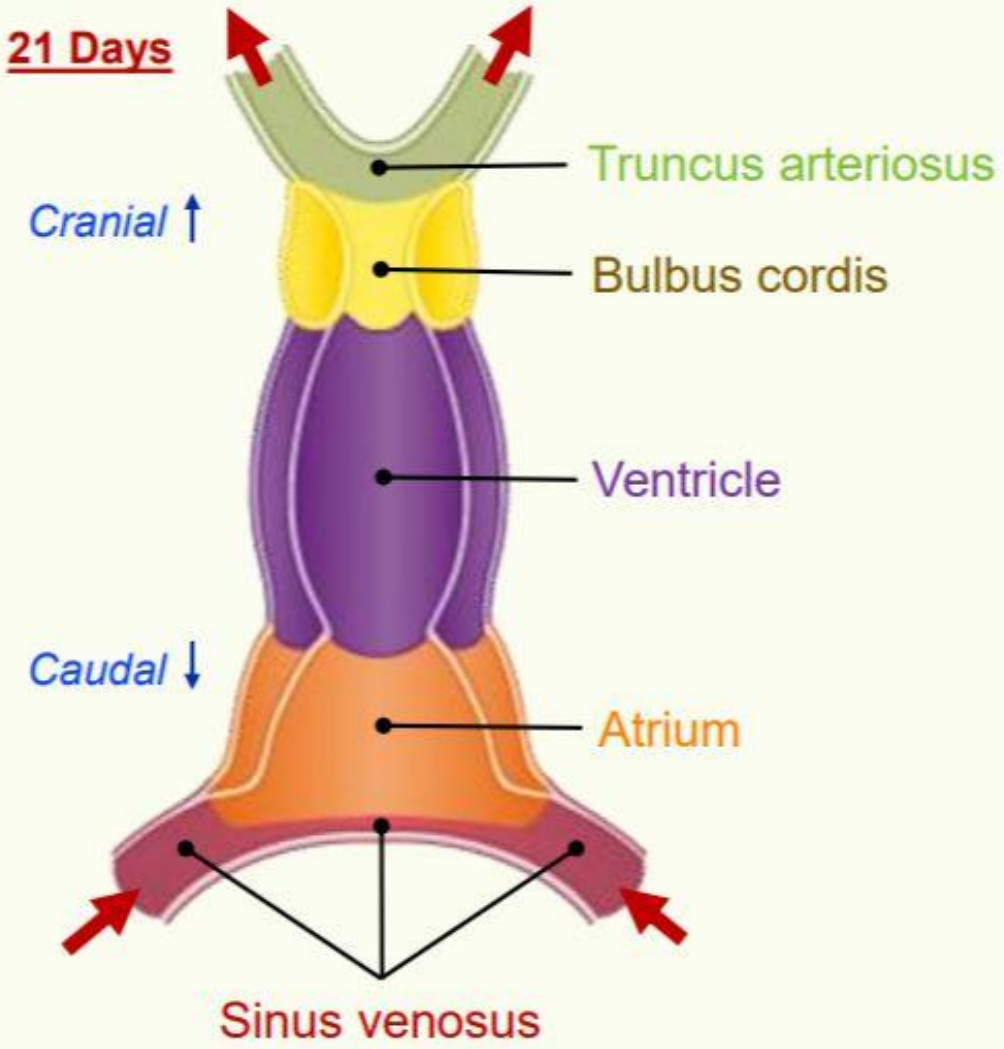


Development of Heart

The Heart Tube

- Heart tube has regions:
  - Sinus venosus *(venous inflow)*
  - Primitive atrium
  - Primitive ventricle
  - Bulbus cordis
  - Truncus arteriosus *(arterial outflow)*





Development of Heart

- **Truncus arteriosus** → ascending aorta, pulmonary trunk
- **Bulbus cordis** → RV
- **Primitive Ventricle** → LV
- **Primitive Atrium** → RA , anterior wall LA, right auricle, left auricle
- **Sinus venosus** → posterior wall RA, coronary sinus, SA node

The Heart Tube

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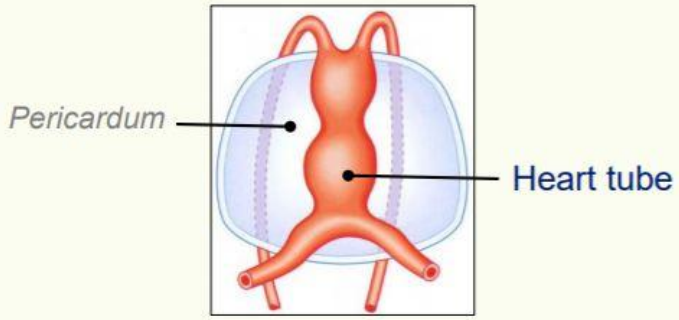
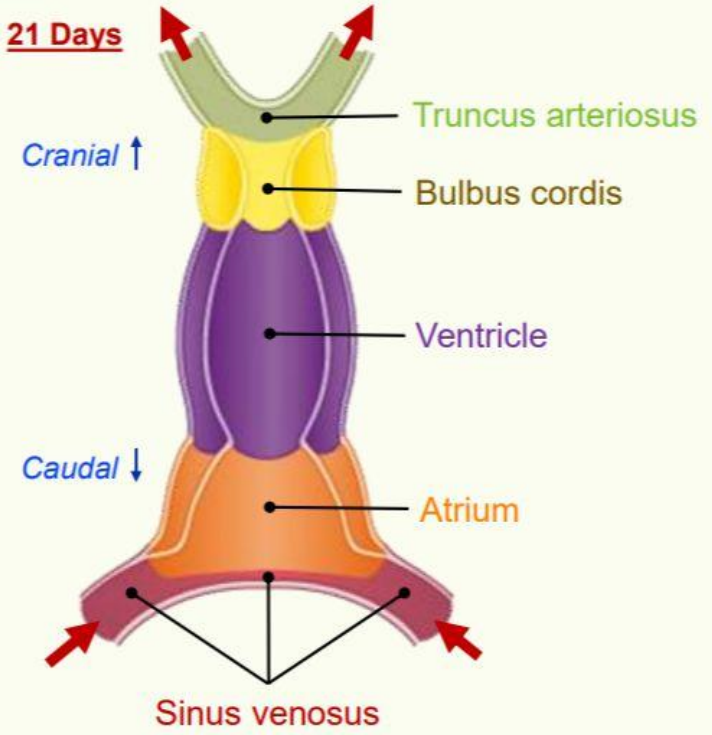




Development of Heart

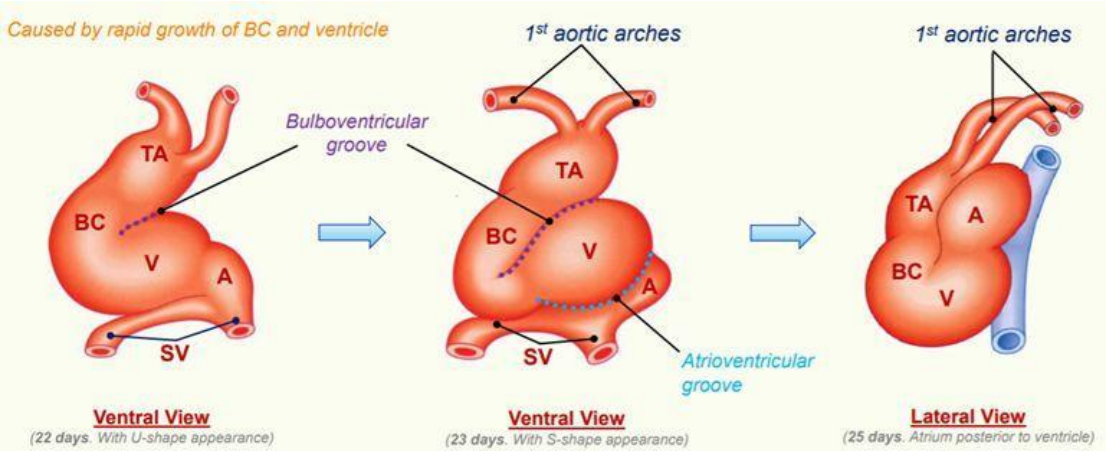
HEART TUBE FOLDS:

★ heart tube folds + regions grow ⟶ ventricle and bulbus cordis grow most

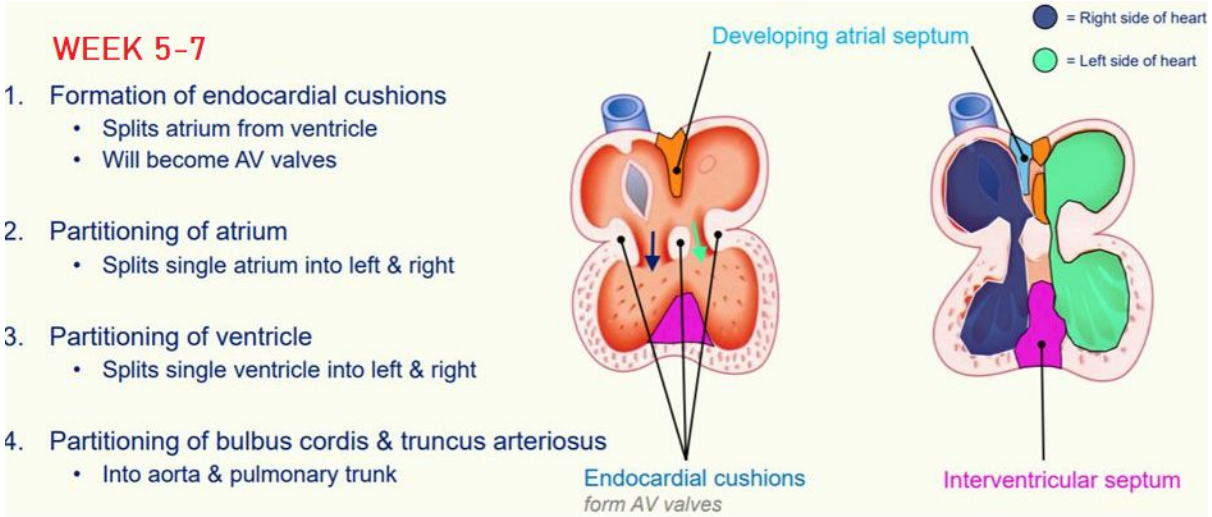
★ ventricle grows most ⟶ causes deepening of bulboventricular groove and appearance of atrioventricular groove

★ Folding of heart tube gives shape of adult heart

★ Now needs to be partitioned internally to separate single tube into 4 chambers

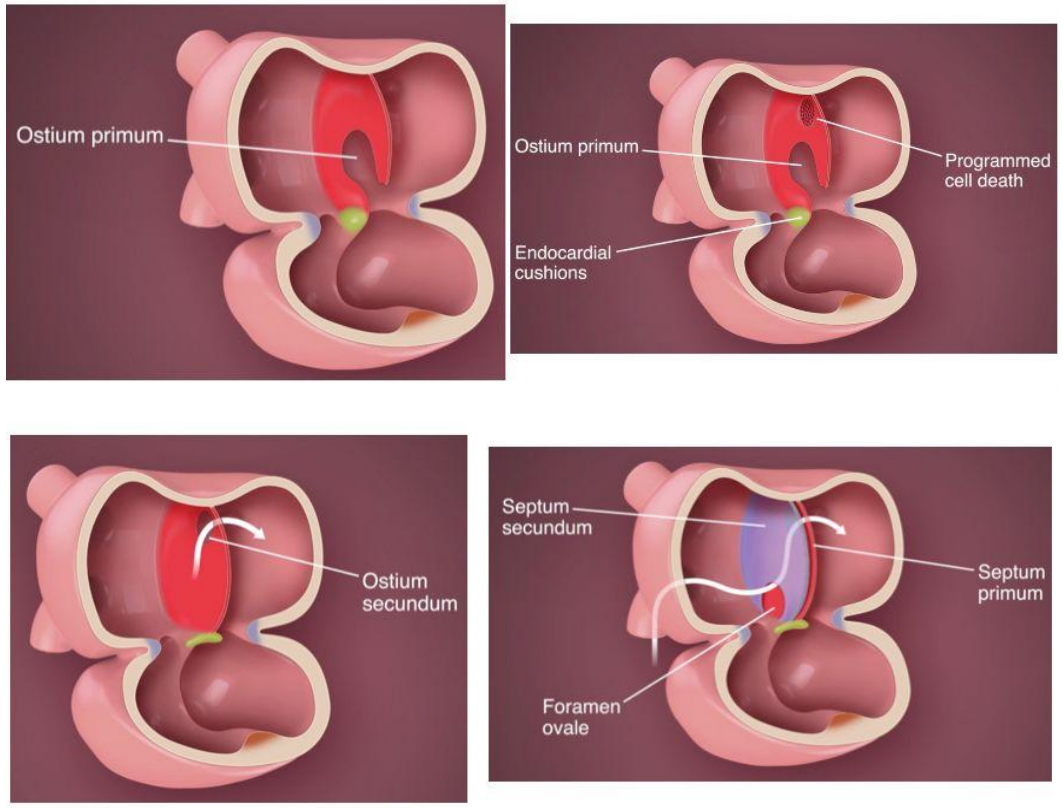


HEART PARTITION:



Partitioning of atria(wks 5-7)

1. **septum primum** forms, with a hole inside = **foramen primum**
2. As foramen primum is closing, apoptosis occurs further up septum primum
3. Now foramen primum is closed, and **foramen secundum** is formed as a result of apoptosis
4. **septum secundum** forms in RA, with another hole – **foramen ovale** → Blood flows between the two atria through this hole



•In new borns, the septum primum and secundum are forced together, due to increased pressure in atria = holes close

What forms the **foramen ovale**?

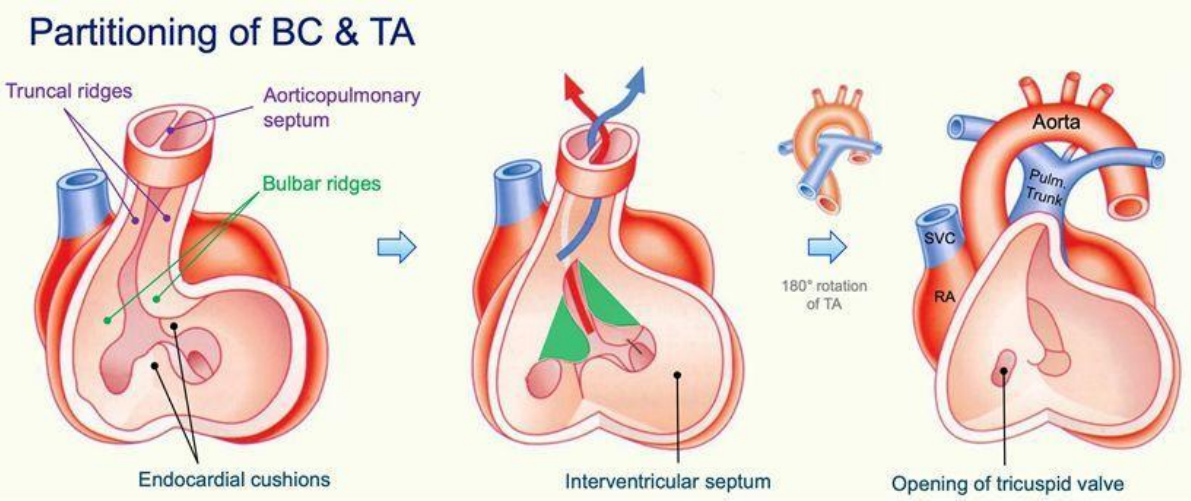
***Septum secondum** (lies in front of septum primum) → allows blood to move from right atrium → left atrium (only one direction).

*180 degrees rotation of the truncus arteriosus → forms final arrangement of aorta & pulmonary trunk.

*Bulbus cordis is now part of the right ventricle.

Partitioning of the Bulbus Cordis and Truncus Arteriosus

- aorticopulmonary septum splits aorta from pulmonary trunk
- There is a 180 degree rotation of the truncus arteriosus, so that the pulmonary trunk sits anteriorly and the aorta, posteriorly



Division of sinus venosus

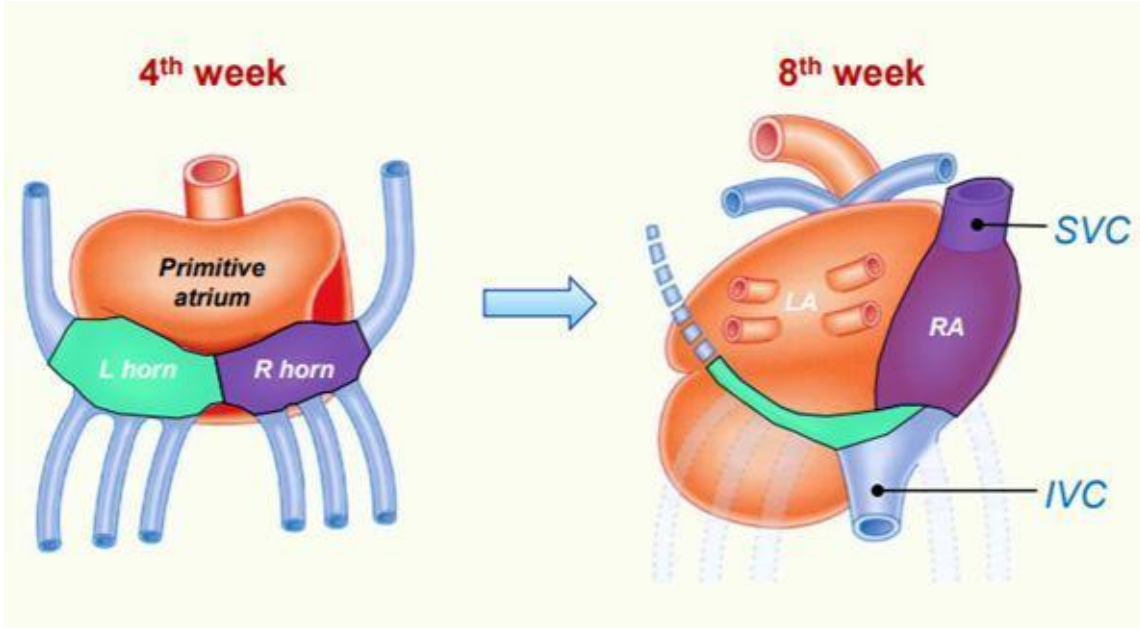
Sinus Venosus directs venous inflow into heart – has right and left horn

Left Horn:

Regresses to become the **coronary sinus**

Right Horn:

Enlarges to become **part of the SVC and right atrium**



FETAL circulation

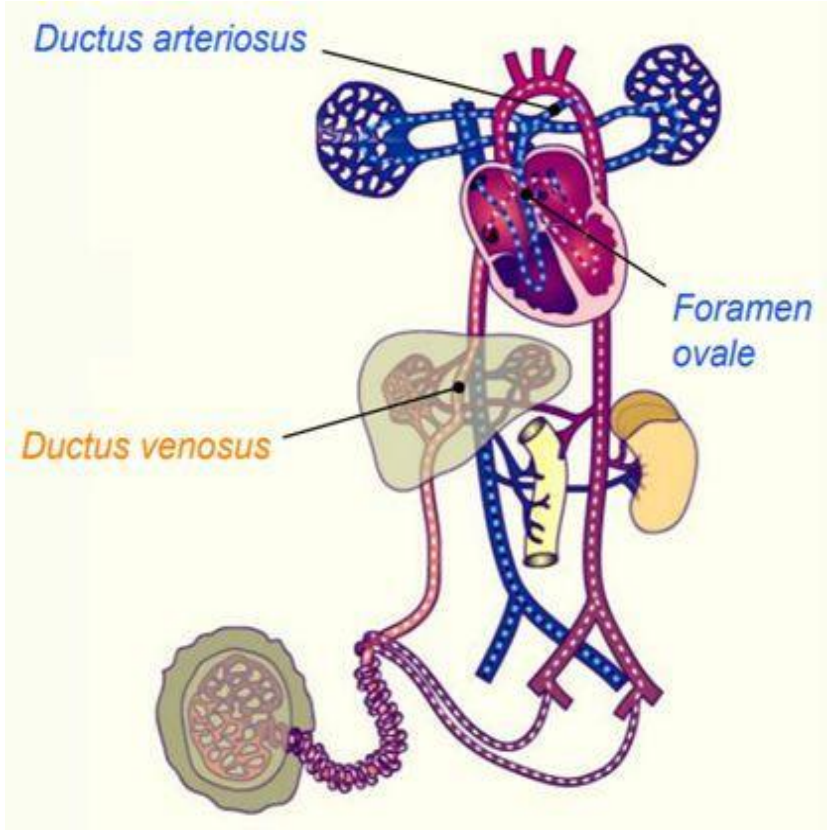
Foetal circulation similar to adults – BUT has 3 vascular shunts which help reduce pressure in developing heart, bypass lungs and bypass liver (which would use all O2 before it can circulate)

3 Vascular Shunts:

Ductus venosus → blood bypasses liver

Foramen ovale → blood bypasses lungs (RA to LA)

Ductus arteriosus → blood bypasses lungs (pulmonary trunk to aorta)



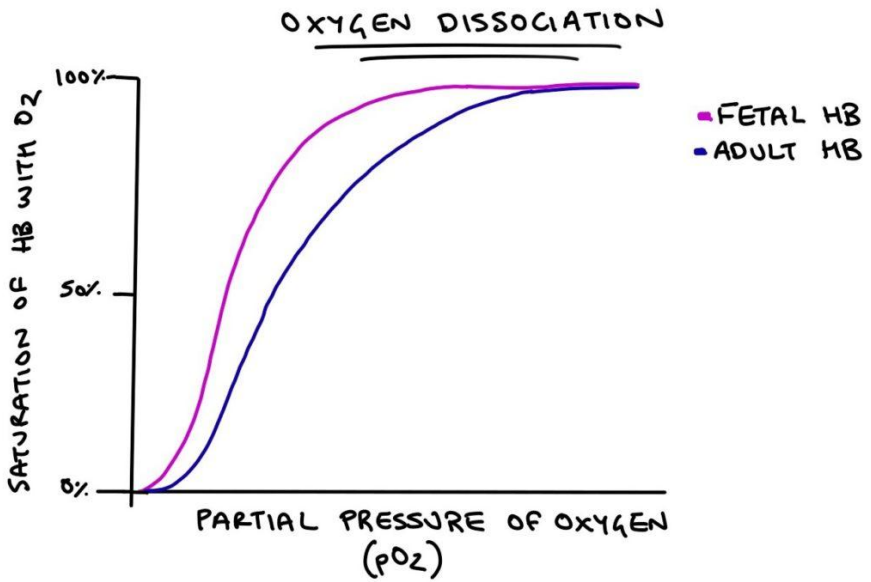
1.Ductus venosus takes oxygenated placental blood into IVC Reaches heart & mixes with venous blood from SVC.
2.Bypasses liver to prevent liver from taking up oxygen.
3.Foramen ovale and Ductus arteriosus prevent **90%** of blood from going to lungs; Redirect it into aorta.
What percentage of foetal circulating blood is sent to the lungs?: Around 10% of blood is sent to lungs.

Why send only 10% to lungs:
*Lungs develop much later than heart.
*Pulmonary vessels cannot handle full circulatory load.
*Low O2 in foetus increases pulmonary resistance and over stresses.

2 Shunts are better than 1:
*Pressure & angle means O2-rich blood in IVC enters right atrium → left atrium (via foramen ovale).
*Remainder of blood from SVC/coronary sinus passes into right ventricle.
Why does the right ventricle need blood to pump? In order to develop/prepare for functioning at full capacity in neonate.

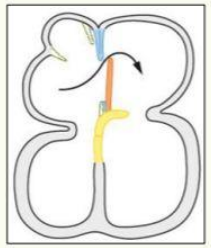
Fetal Haemoglobin

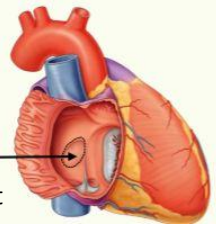
★ O2 availability much lower in fetus than adult
★ Has much higher affinity for O2 binding than adult haemoglobin
★ Becomes saturated at lower pO2
★ Switches to adult Hb within 6 months as site of haematopoiesis changes

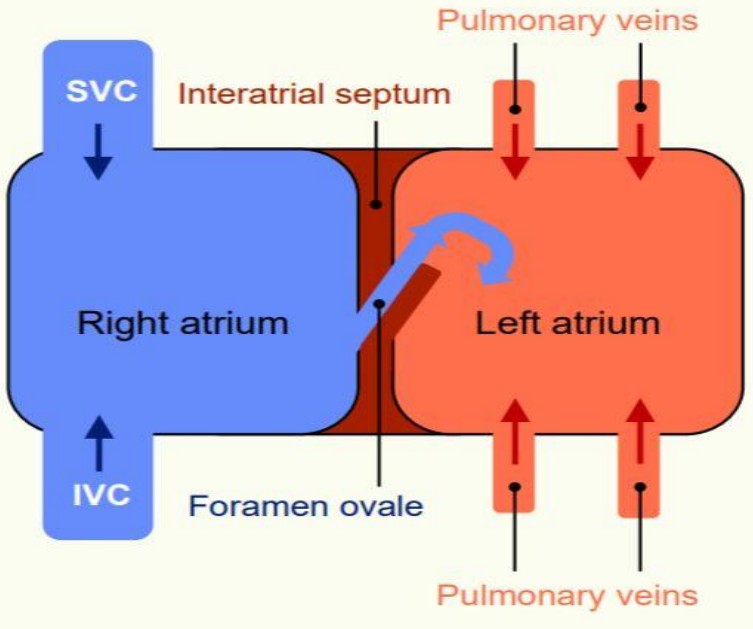


FETAL circulation

- In fetus
  - Foramen ovale is flap-like valve
  - Blood flows from RA to LA
- After birth
  - Increased blood flow into LA from pulmonary veins raises pressure in LA
  - Flap *should* close
  - Fusion in ~3 months
- In adult
  - Seen in RA as 'fossa ovalis'







Ductus arteriosus closing

In fetus:

♡ prostaglandins (PGE2 and PGE1) secreted by placenta

♡ this inhibits vasoconstriction of ductus arteriosus and keeps it patent (open/unobstructed) as a shunt

After birth:

♡ PGE2 and PGE1 levels drop

♡ ductus arteriosus vasoconstricts until lumen is fully closed

→ It's remnant = ligamentum arteriosum in adults

Ductus venosus closing

In fetus:

★ allows blood to mostly bypass liver

After Birth:

★ Same prostaglandin mechanism as in ductus arteriosus

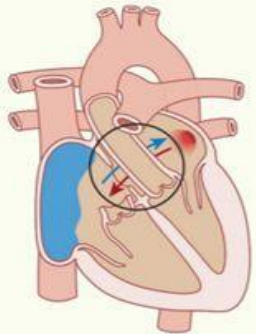
★ sphincter contracts around DV = forces blood into liver sinusoids

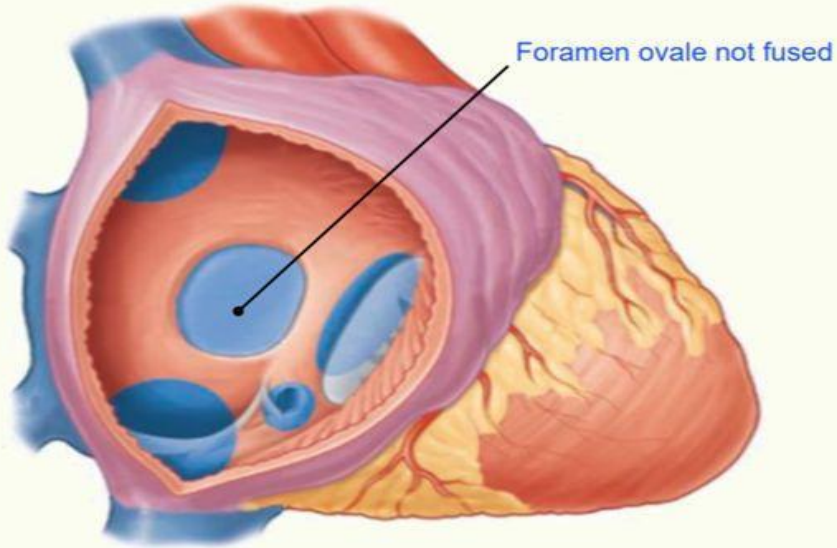
★ Empty DV closes/fuses

★ Seen in adults as ligamentum venosum → In posterior view LV is between L + R lobes

Atrial Septal Defects (ASDs)

- Patent foramen ovale
  - "Hole in the heart" → hole between atria
  - Most common type of ASD
  - May present as cyanosis
  - More noticeable in later infancy

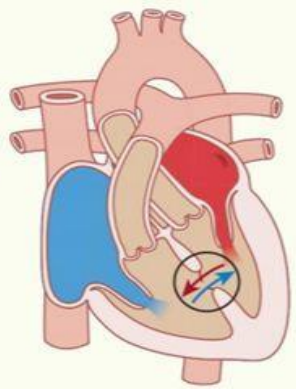


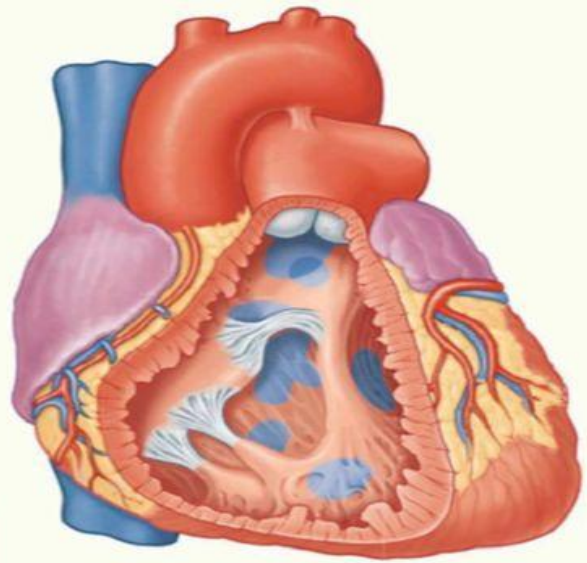


View into Right Atrium
(showing common sites of ASDs)

Ventricular Septal Defects (VSDs)

- Partial absence of ventricular septum
  - Reasonably common
  - Blood shunts down pressure gradient *(left to right)*
- Can be complete absence of septum
  - Very rare
- May combine with ASDs and other issues
  - Great vessel anomalies, etc.





View into Right Ventricle
(showing common sites of VSDs)

Embryology
QUESTIONS

1. What does the Primitive Atrium become?

→ RA , anterior wall LA, right auricle, left auricle

→ LA , anterior wall RA, right auricle, left auricle

→ Right and left ventricles

→ RA and ascending aorta

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→ RA , anterior wall LA, right auricle, left auricle

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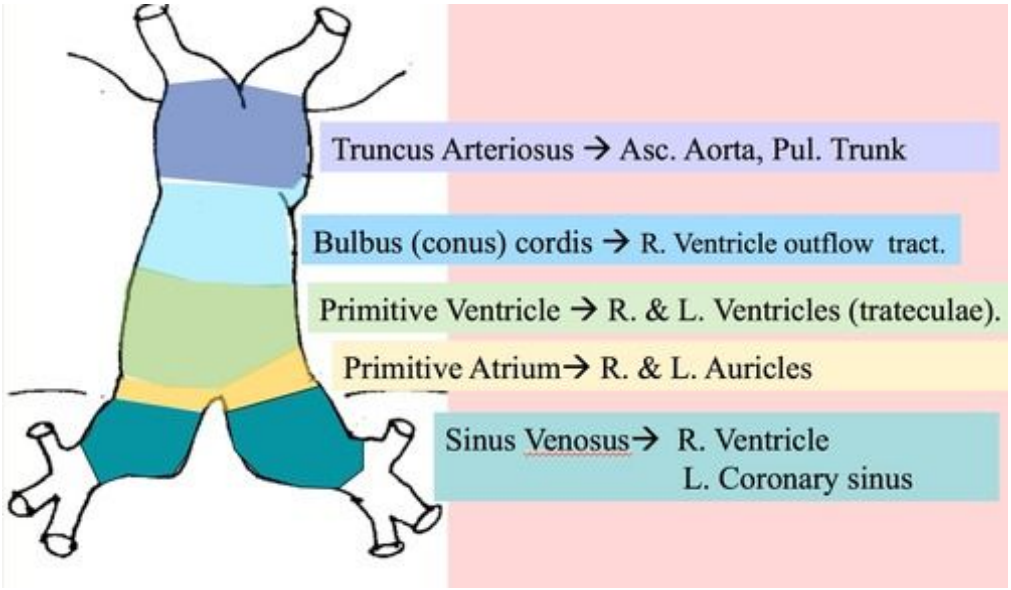
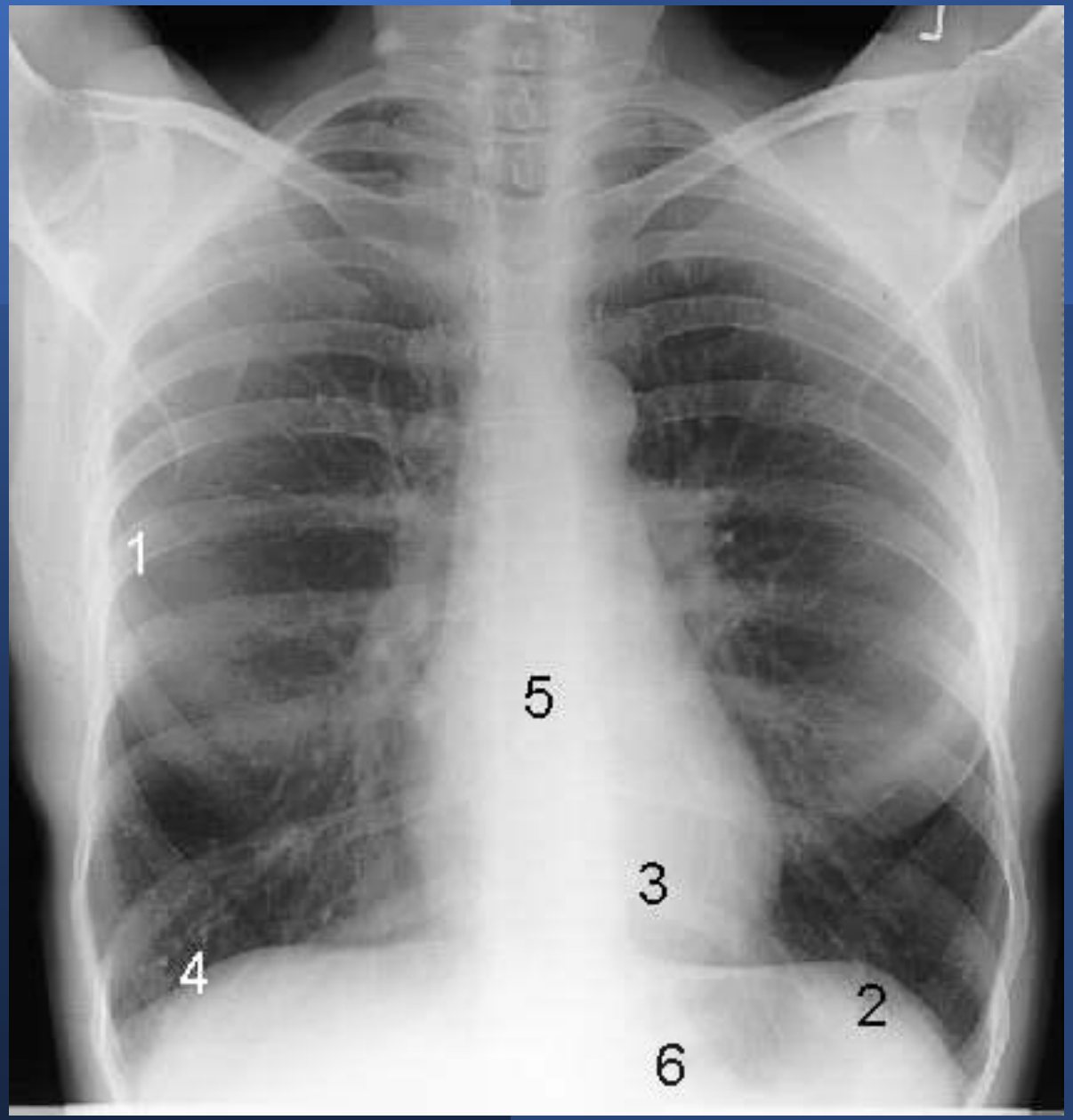
→ RA and ascending aorta

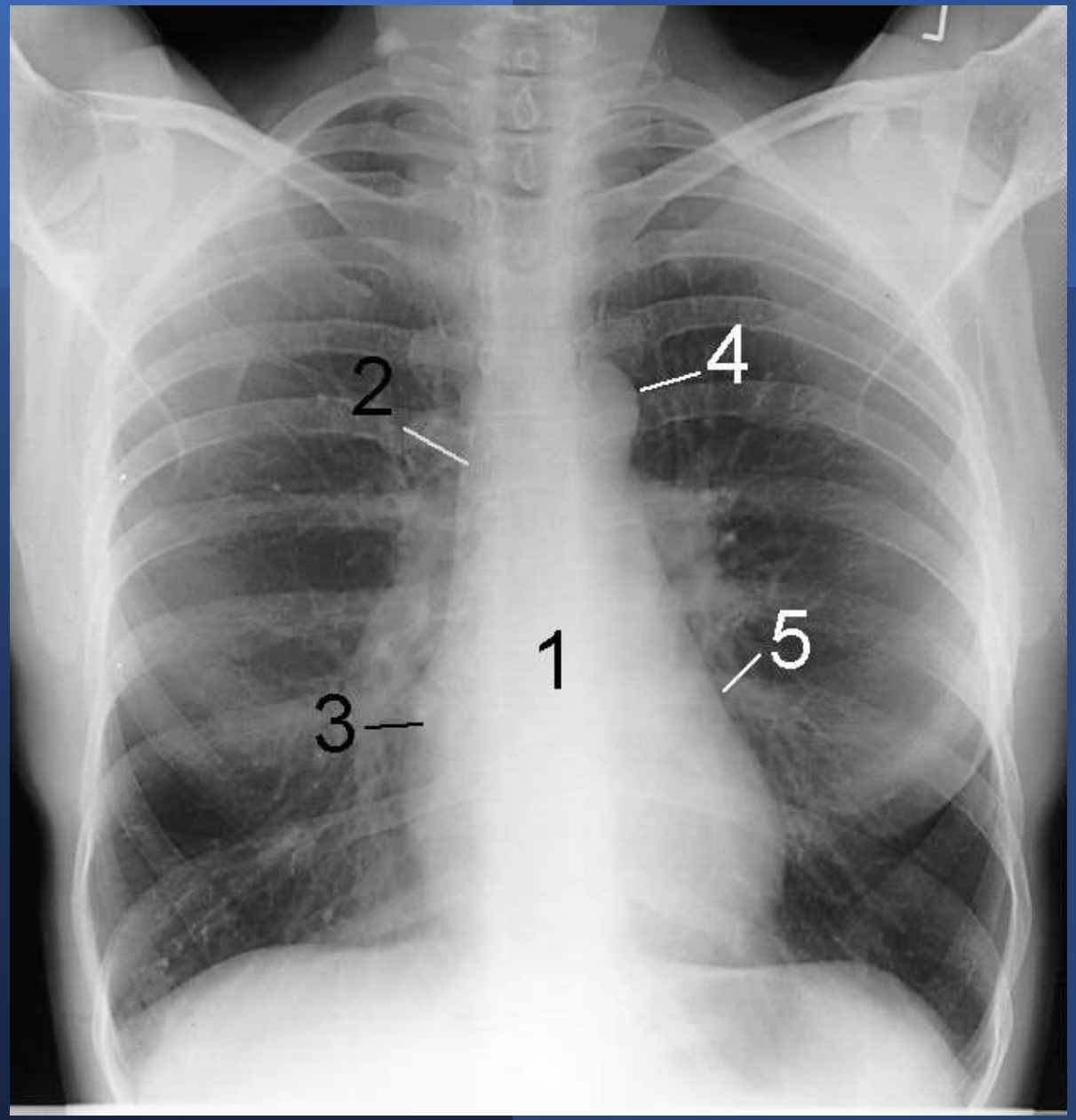


RADIOLOGY

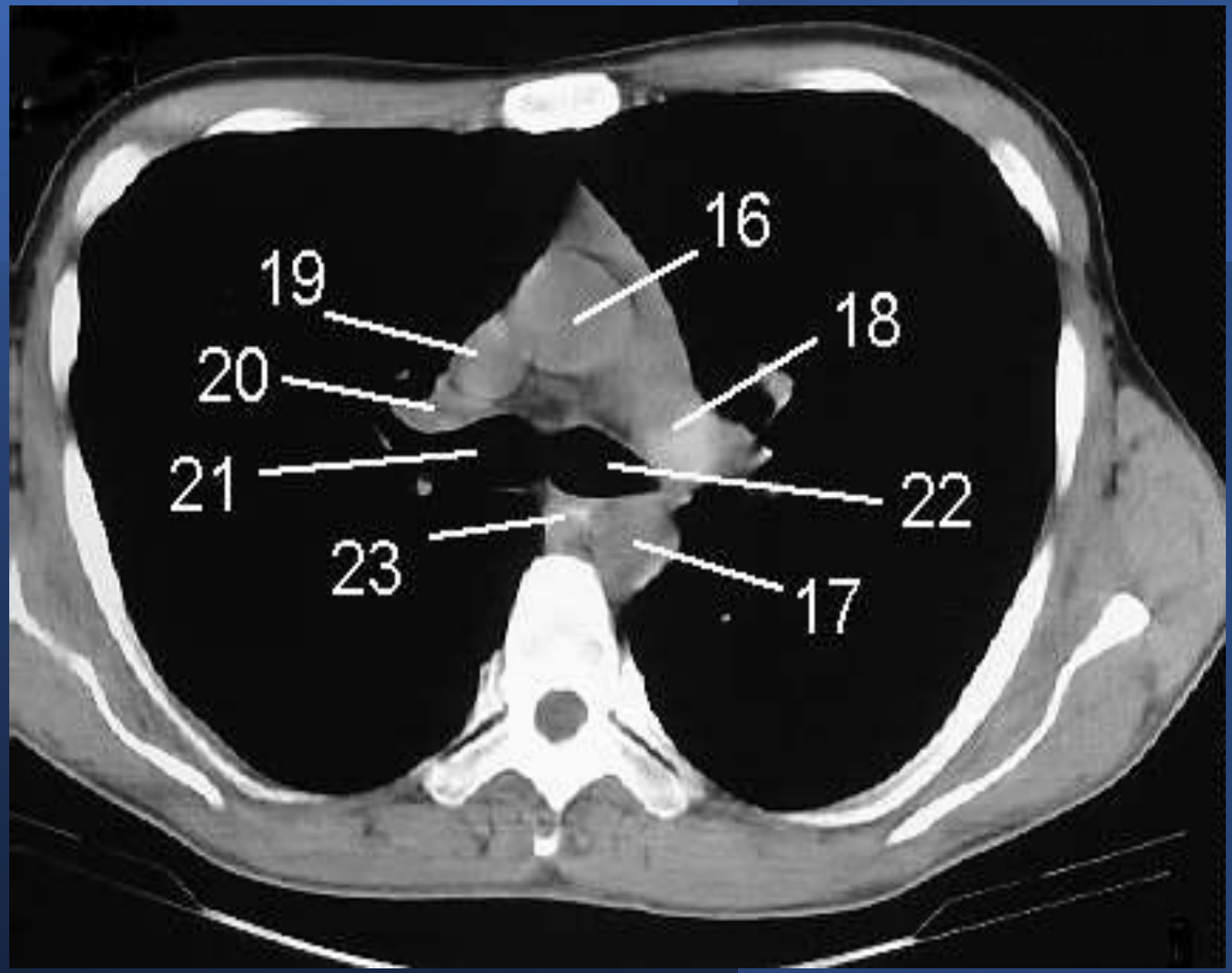
1. Rib
2. Left dome (Cupolae) of the Diaphragm
3. Posterior of Rib showing through Heart
4. Right dome (Cupolae) of the Diaphragm
5. Heart Shadow
6. Diaphragm (gas bubble of stomach visible)



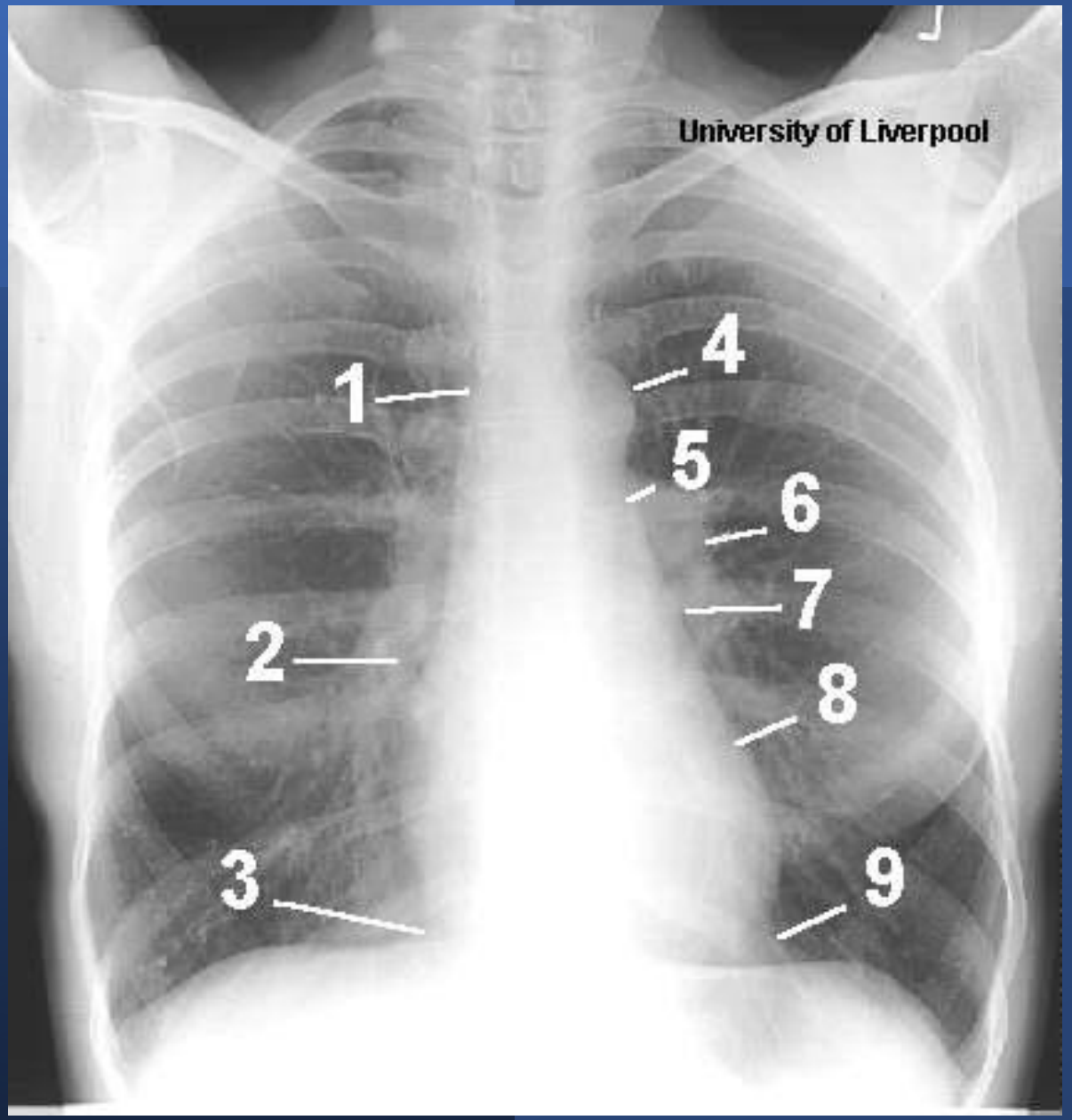
1. Central Mediastinal Shadow
2. Superior Vena Cava
3. Right Atrium
4. Aorta
5. Left Ventricle



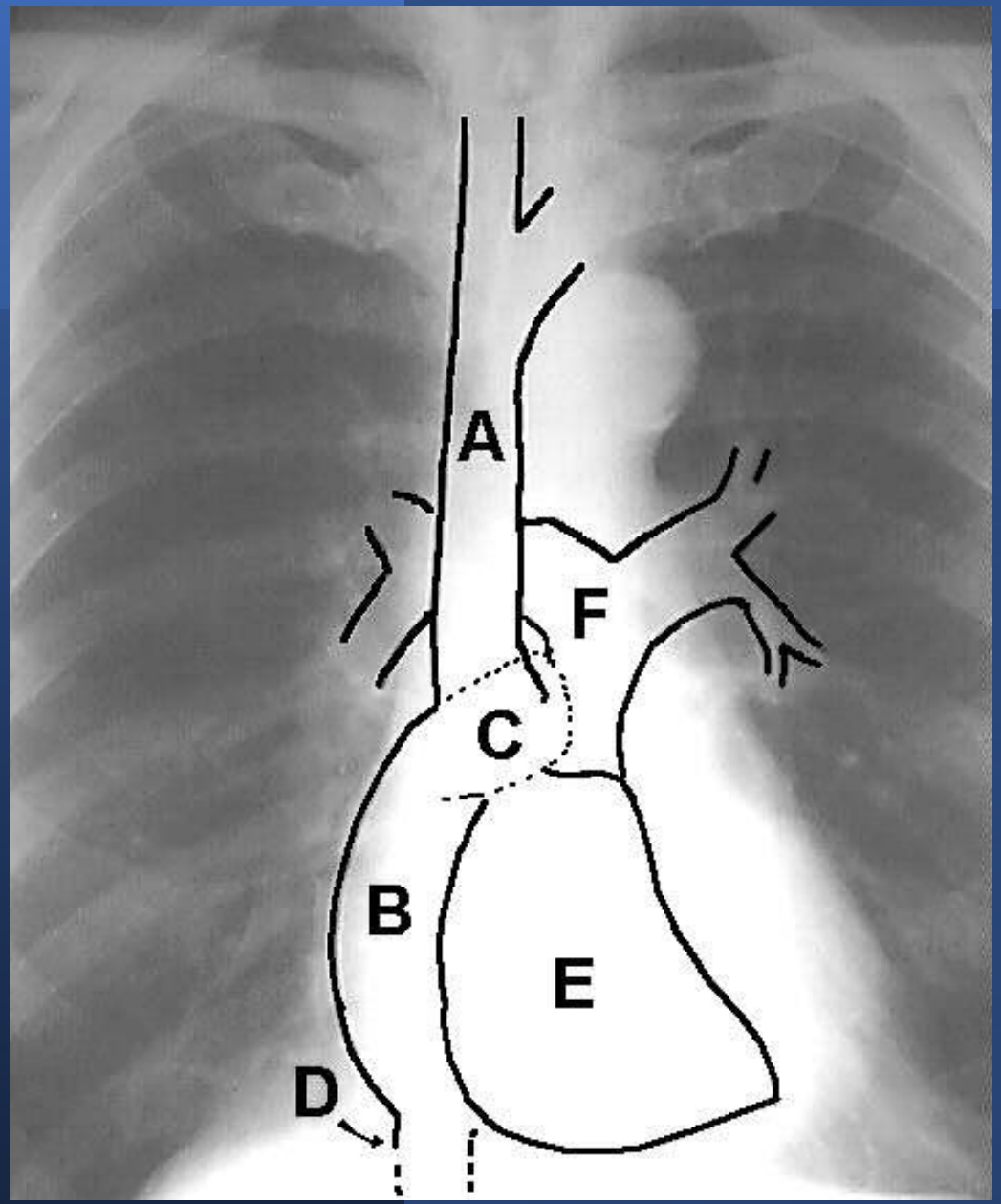
16. Ascending Aorta
17. Descending Thoracic Aorta
18. Left Pulmonary Artery
19. Superior Vena Cava
20. Right Pulmonary Artery
21. Right main Bronchi
22. Left main Bronchi
23. Oesophagus



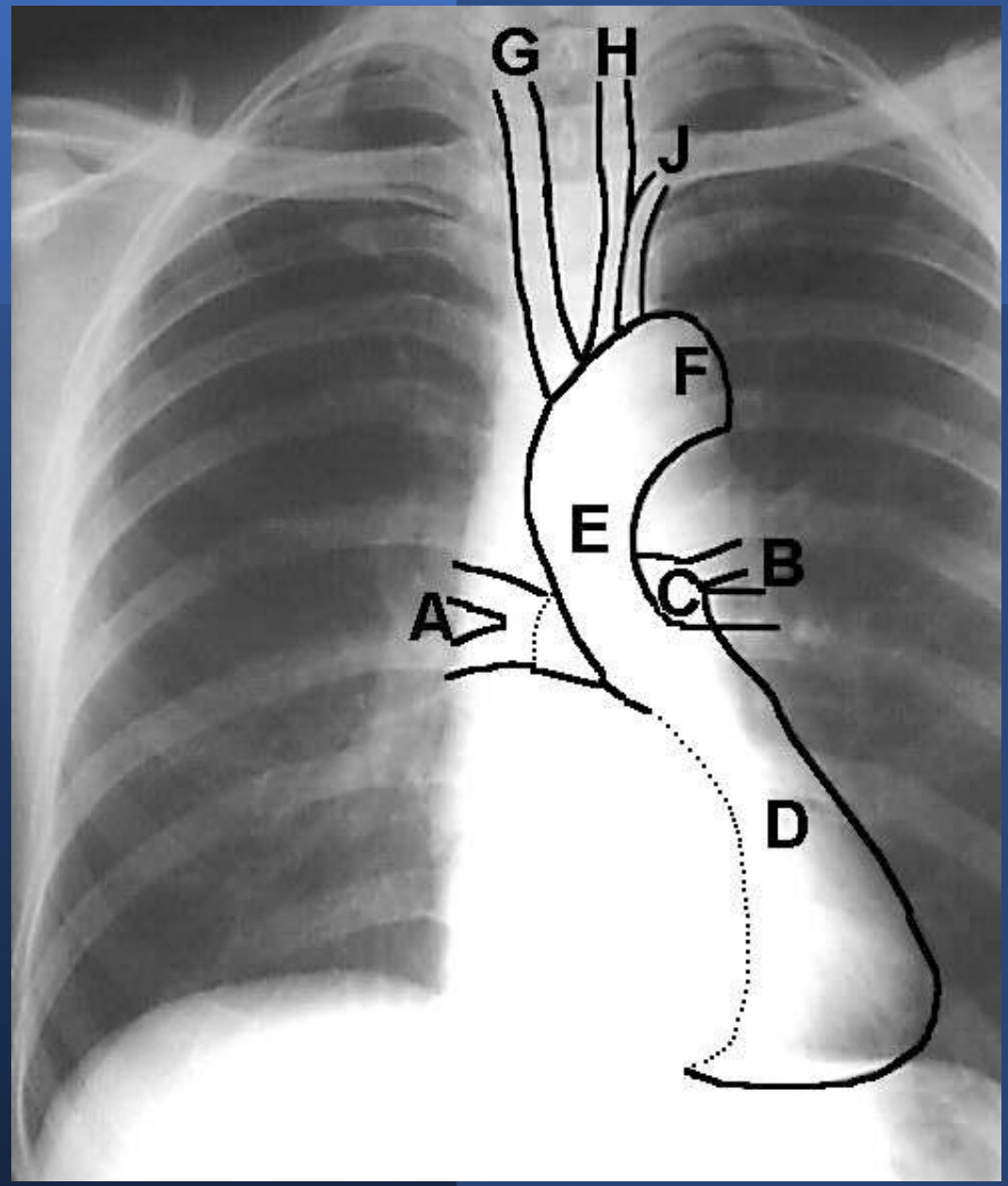
1. Superior Vena Cava
2. Right Atrium
3. Inferior Vena Cava
4. Arch of Aorta (Aortic Knuckle)
5. Left Pulmonary Trunk
6. Left Pulmonary Artery
7. Auricle of left atrium
8. Left ventricle
9. Left Cardiophrenic angle



A. Superior Vena Cava
B. Right Atrium
C. Right Auricle
D. Right Cardiophrenic Angle
E. Right Ventricle
F. Pulmonary Trunk



A. Right Pulmonary Vein
B. Left Pulmonary Vein
C. Left Atrium (cannot be seen)
D. Left Ventricle
E. Ascending Aorta
F. Arch of Aorta (Aortic Knuckle)
G. Brachiocephalic Trunk
H. Left Common Carotid Artery
J. Left Subclavian Artery

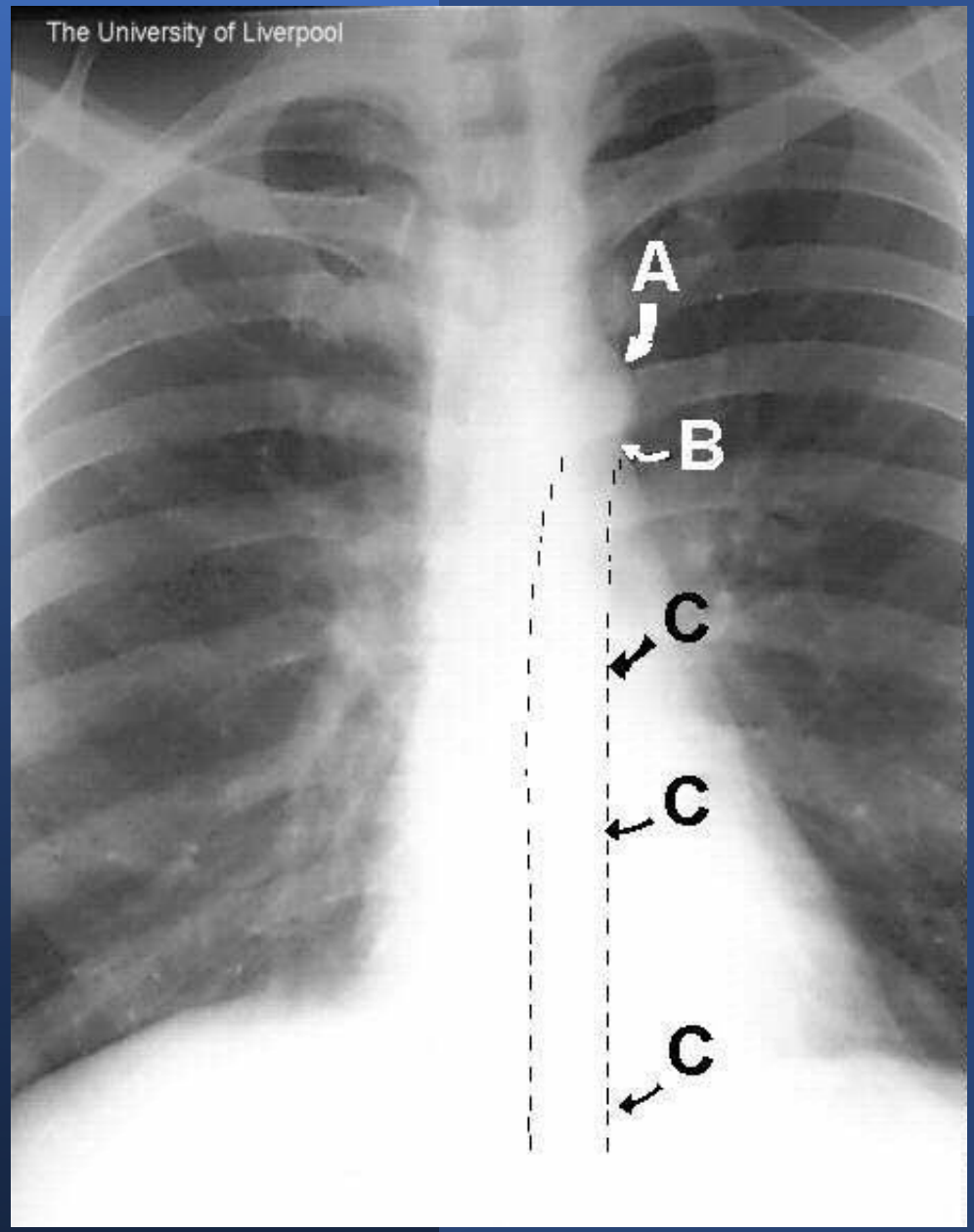


A. Arch of Aorta (Aortic Knuckle), found at the level of the Sternal angle (angle of Louis)

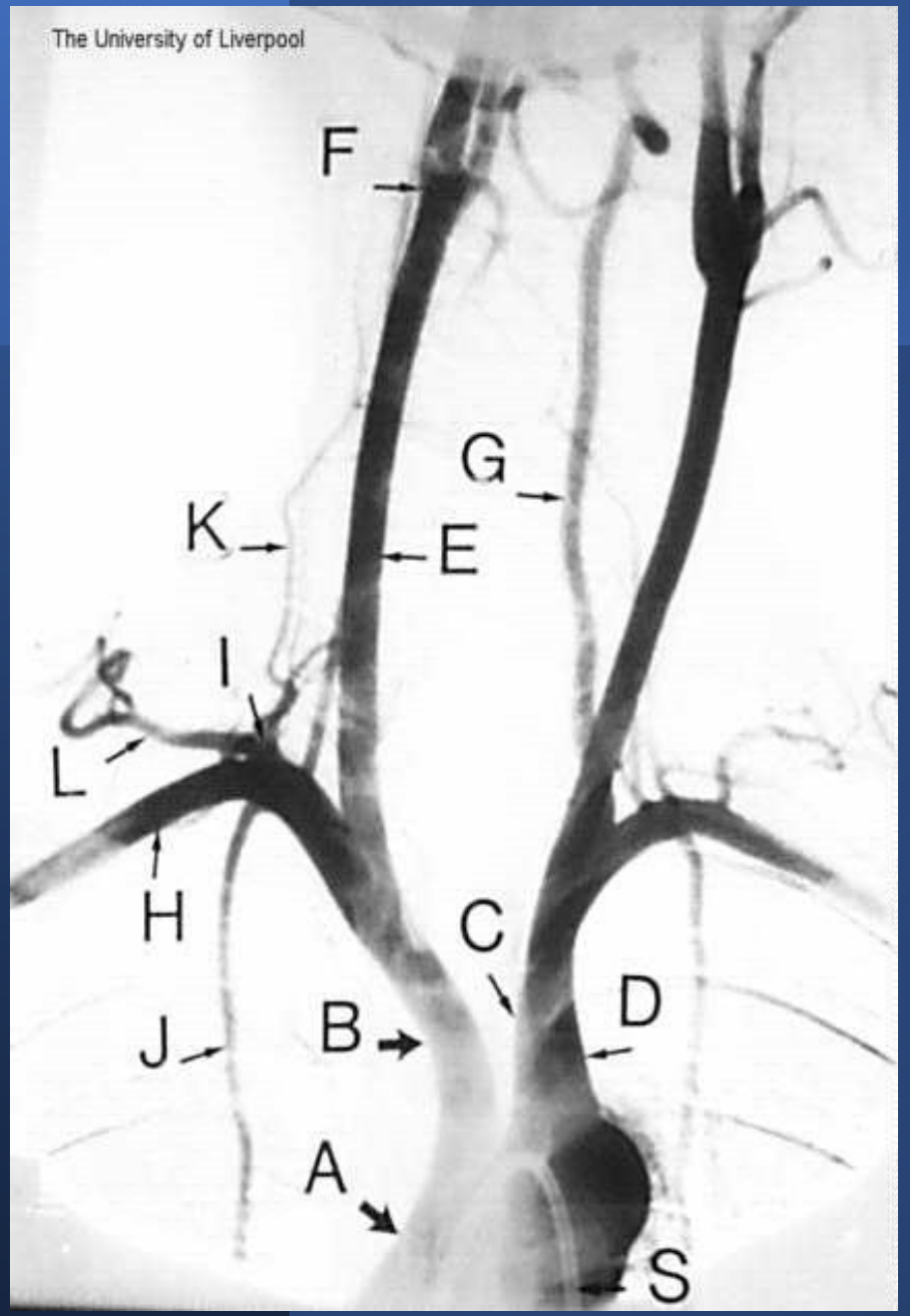
B. The arch of the aorta passes backwards and to the left behind the lower part of the **Manubrium of the sternum** to reach the level of the **4th thoracic vertebra.**

   Aortic arch lies superior to the left bronchus.

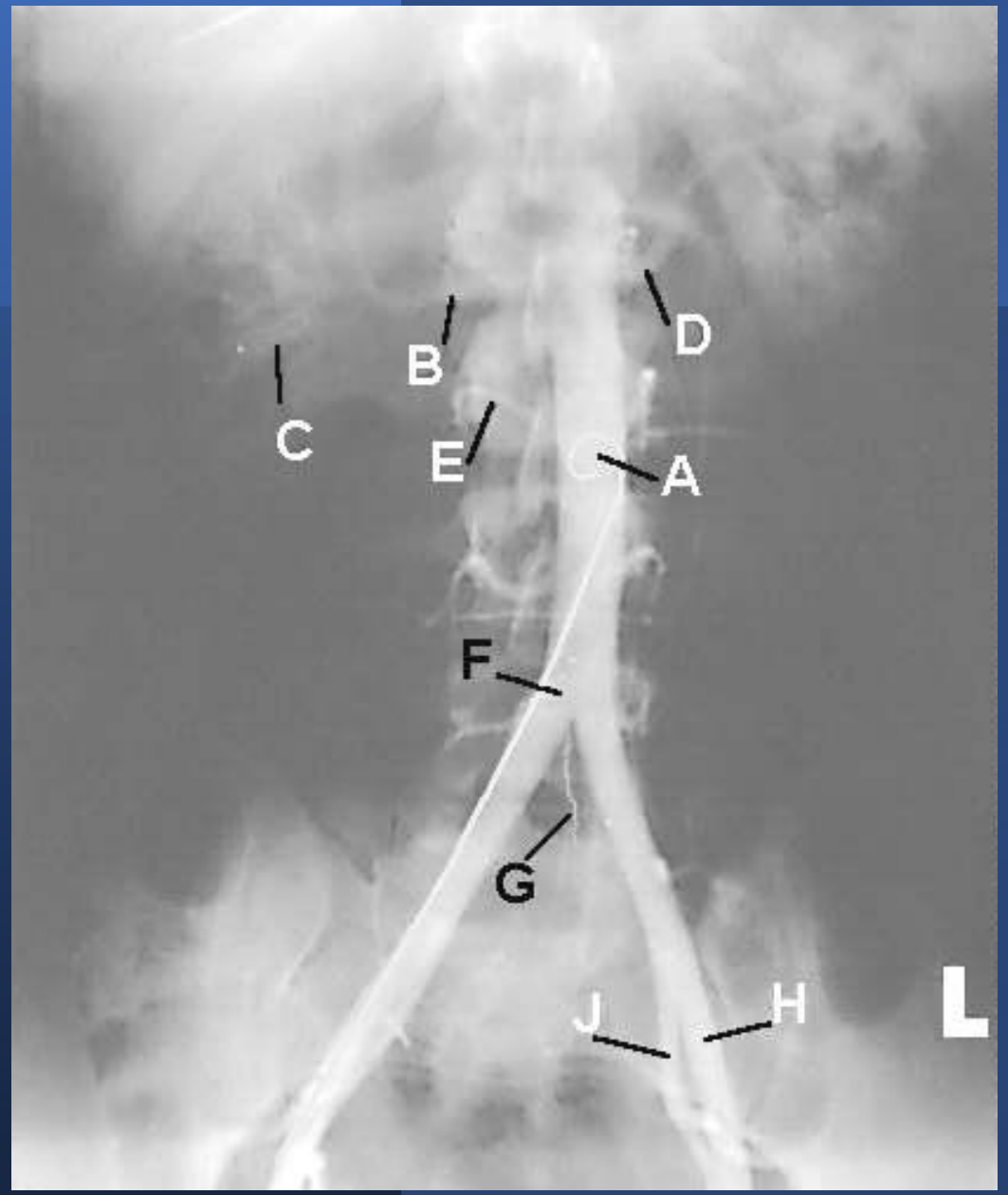
C. Descending Aorta is said to commence level with the lowest part of the body of the 4th thoracic vertebra.



A. Arch of the Aorta
B. Brachiocephalic artery
C. Left common Carotid artery
D. Left Subclavian artery
E. Common Carotid artery
F. Bifurcation of common carotid Internal & External carotid arteries
G. Left Vertebral artery
H. Right Subclavian
I. Thyrocervical trunk
J. Internal Thoracic artery
K. Right inferior Thyroid artery
L. Right transverse Cervical artery
S. Catheter in descending Aorta



A. Catheter in Abdominal Aorta
B. Right Renal artery
C. Right Kidney
D. Left Renal artery
E. 3rd Lumbar segmental artery
F. R/L Common Iliac arteries
G. Median Sacral artery
H. Left External Iliac artery
J. Left Internal Iliac artery



Questions

a) aortic valve
b) atrioventricular valve
c) bicuspid/mitral valve
d) chordae tendineae
e) conus arteriosus
f) crista terminalis
g) fossa ovalis
h) ligamentum arteriosum
i) musculi pectinati
j) papillary muscle
k) pulmonary valve
l) septomarginal trabecula
m) trabeculae carneae
n) tricuspid valve

A prominent ridge on the interior of the ventricle containing Purkinje fibres and facilitating coordinated contraction of the right ventricle

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The site of right-left shunting in the foetus, allowing oxygenated blood to the proximal aorta

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The contractile structure which prevents valve cusps from everting or prolapsing

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The structure through which blood enters the left ventricle

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The structure through which blood enters the left ventricle