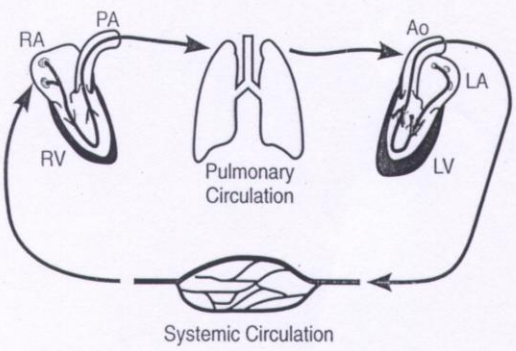
ANATOMY OF CARDIOVASCULAR SYSTEM FOR THIRD YEAR MEDICAL STUDENTS

Lectures :- prof. Faraj Al – Bustami
MD, Ph.D, FRCS(I)

References:-

1- Clinical Anatomy. R. Snell . Lippincott.
2- Grays Atlas of Anatomy. Drake et al Churchill livingstone.
3- Illustrated physiology . theis- theim

Anatomy of the heart	**Prof. Faraj AlBustami**
Anatomy of the great vessels	**Prof. Faraj AlBustami**
Anatomy of the Peripheral arteries	**Prof. Faraj AlBustami**



URE 1-1 Overview of the cardiovascular system. The right side of the heart, pulmonary circulation, left side of the rt, and systemic circulation are arranged in series. *RA*, right atrium; *RV*, right ventricle; *PA*, pulmonary artery; *Ao*, ta; *LA*, left atrium; *LV*, left ventricle.

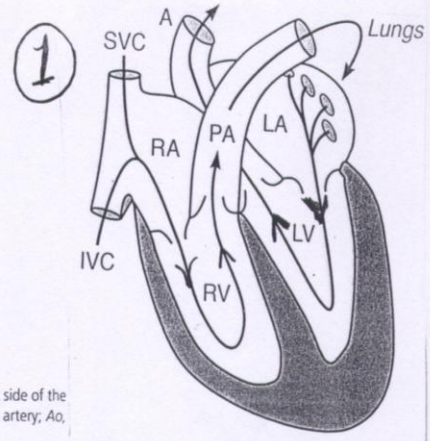


FIGURE 1-3 Blood flow within the heart. Venous blood returns to the right atrium (*RA*) via the superior (*SVC*) and inferior vena cava (*IVC*). Blood passes from the RA into the right ventricle (*RV*), which ejects the blood into the pulmonary artery (*PA*). After passing through the lungs, the blood flows into the left atrium (*LA*) and then fills the left ventricle (*LV*), which ejects the blood into the aorta (*A*)

The cardiovascular system (CVS) has two primary components:- the heart and blood vessels . A third component, the lymphatic system does not contain blood but serves an important exchange function in conjunction with blood vessels.

↓

The heart can be viewed FUNCTIONALLY as two pumps with the pulmonary & systemic circulations situated between the 2 pumps.

↓

Each side of the heart has 2 chambers → an atrium
→ a ventricle

Connected by one – way valves called atrioventriclar (AV) valves → The AV valves are designed so that blood can flow only in one direction from the atrium to the ventricles .

→ the pulmonary circulation ? is the blood flow within the lungs that is involved in the exchange of gases between the blood & alveoli.
→ the systemic circulation is composed of all blood vessels within and outside of organs excluding the lungs.

↓

(the left and right heart function in series so that blood is pumped sequentially from the left heart to the systemic circulation → to the right heart → to the pulmonary circulation → then back to the left heart)

HEART ANATOMY
Superficial Anterior View

(2)

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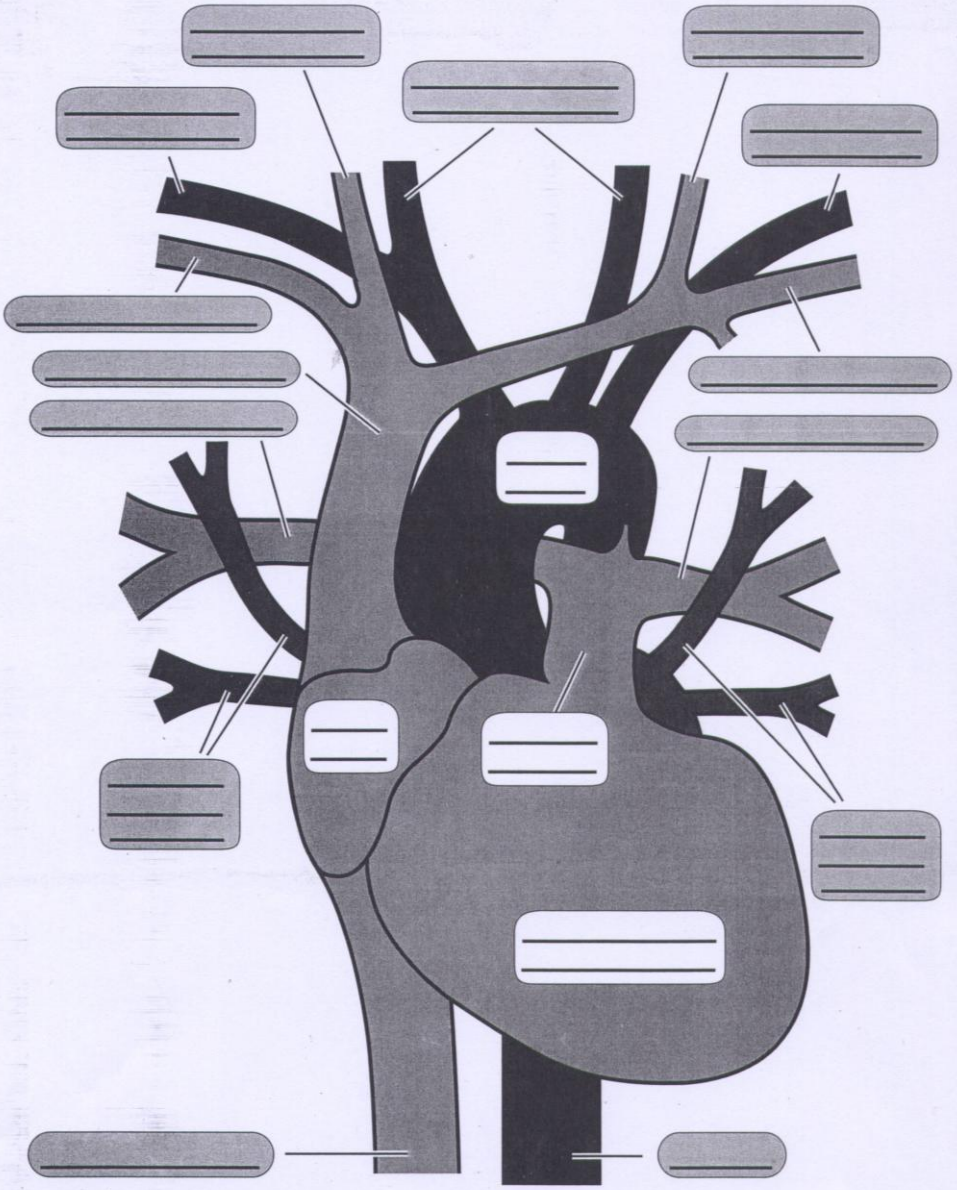
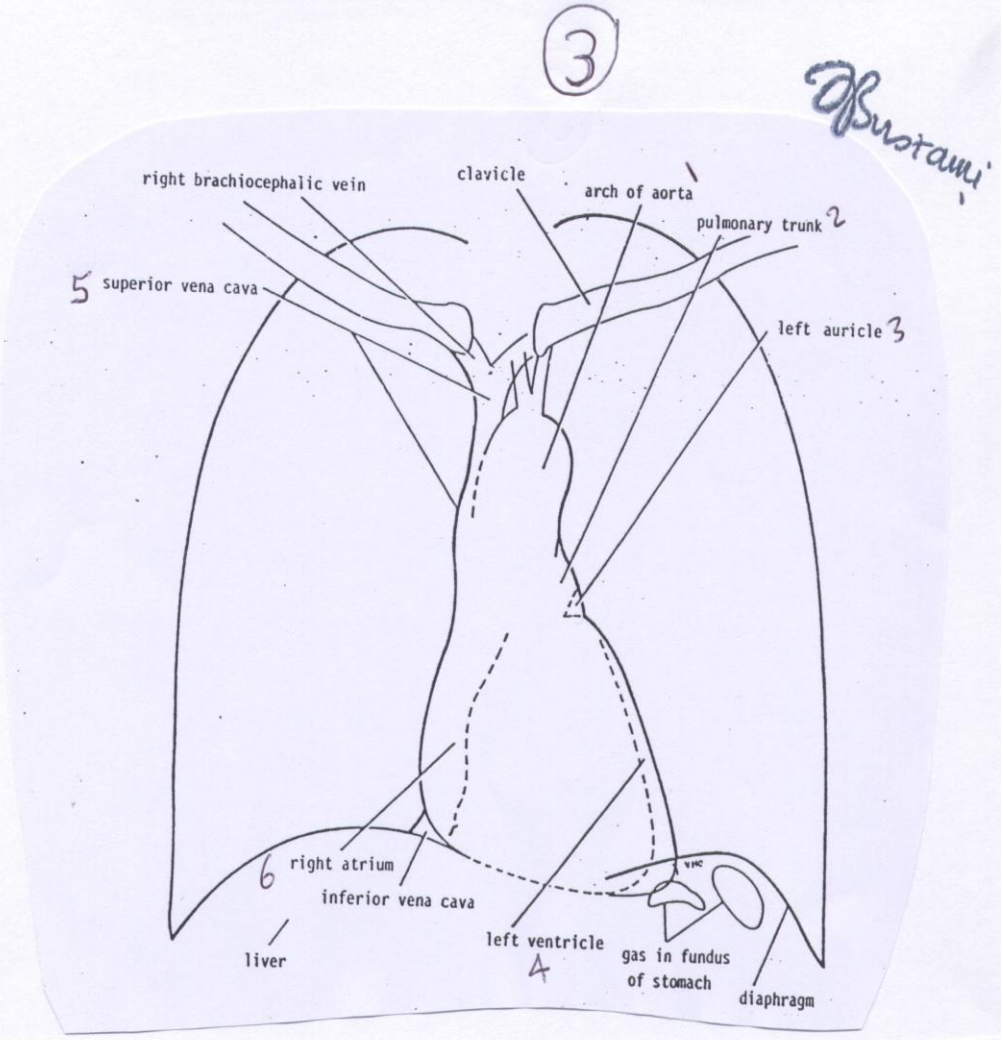


- Name the pointed structures
- What is meant by the major vessels? Do they appear in the above diagram?



- **What forms the left border of the mediastinal shadow?1,2,3,4**
- **What forms the right border of the mediastinal shadow?5,6**
- **Is it normal to find gas below the left dome of the dagram?**
- **Is it normal to find gas below the right dome of the diagram?**
- **<u>The apex of the heart</u>:-**
  a. position (at which space and how far from the sternum?)
  b. formed by……..
  c. what relation to the midclavicular line?
  d. what is the apex beat? Can you feel it?
- **what forms the anatomical base of the heart? Does it appear in an x-ray of the chest?**
- **what is the <u>aortic knuckle</u>**
- **when the <u>apex</u> is <u>shifted downward and outward</u> it indicates enlargement of which chamber of the heart?**

HEART ANATOMY
Chambers and Valves

(4)

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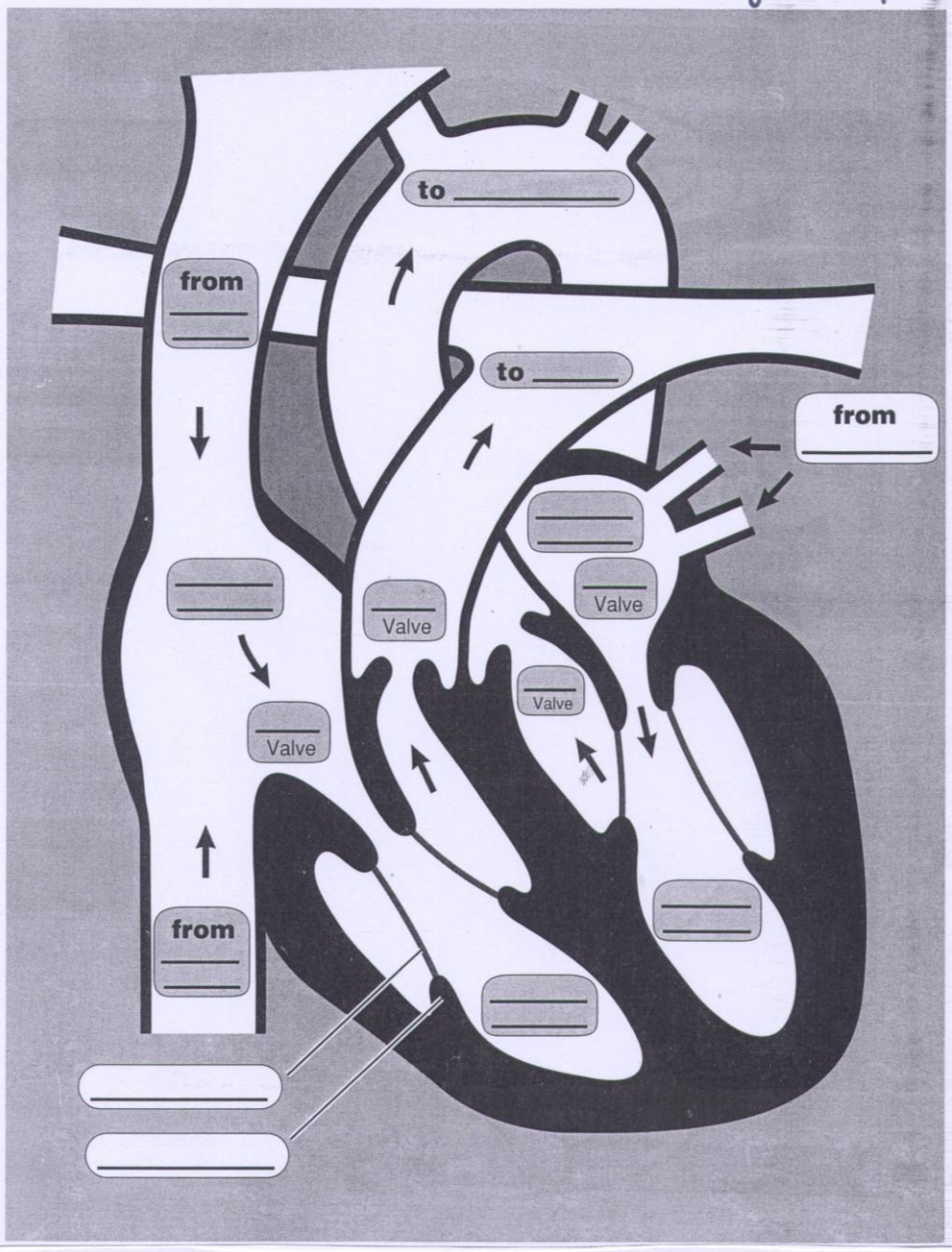
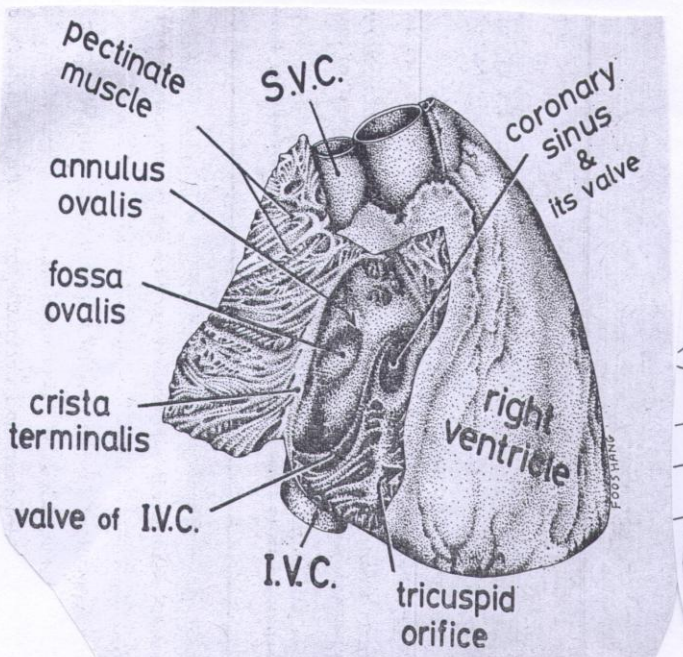


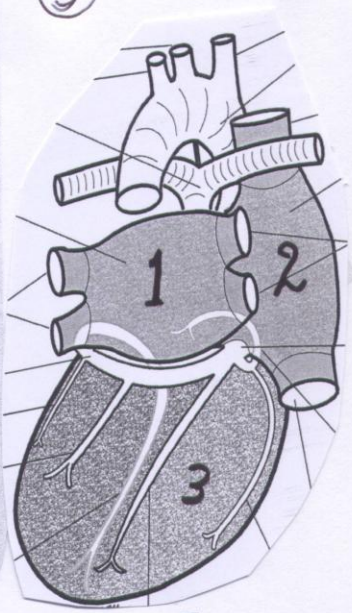
- Describe how blood enters and leaves the heart.
- The four valves (2 A-V and 2- semi lunar) could be closed at the same time (true/ false).
- Opening of the valves is silent but their closure produces the heart sounds

(T/F)



Special features in the inside of the right atrium.

5



1- the crista terminalis separates the anterior rough – walled part of the right atrium (derived embryologically from the primitive atrium) from the posterior smooth part (derived from the right horn of the sinus venosus)
2- what is posterior to the right atrium? (remember that the interatrial septum forms the posterior wall of the right atrium).
3- The fossa ovalis was in the embryo…..?
4- The valve of the inferior vena cava has important function in the embryo??
5- The pressure inside the right atrium is the central venous pressure and is largely affected by the blood volume . If you have a patient with increased central venous pressure and reduced cardiac out put, where is the defect?? Does the patient needs blood transfusion?

6- Identify structures 1 and 2.
7- Structure 1 forms the base of the heart and lies between tow sinuses of pericardium, name these sinuses → ?
→ ?
8- blood flow runs from 2 to 1 in the foetus and is reversed immediately after birth? What is the under lying mechanism?
9- In mitral stenosis blood can flow easily from 1 back into the lungs. Why??
10- In ASD the output of the left ventricle may be reduced. Comment……
11- Atrial fitrillation affecting 1 may result in ischemia of the lower limb. Comment …..
12- Structure 1 forms part of the left border of the heart (true/ false)
13- In ASD structure 3 undergoes hypertrophy (true / false)

During fetal development, the foramen ovale allows blood to pass from the right atrium to the left atrium, bypassing the nonfunctional fetal lungs while the fetus obtains its oxygen from the placenta

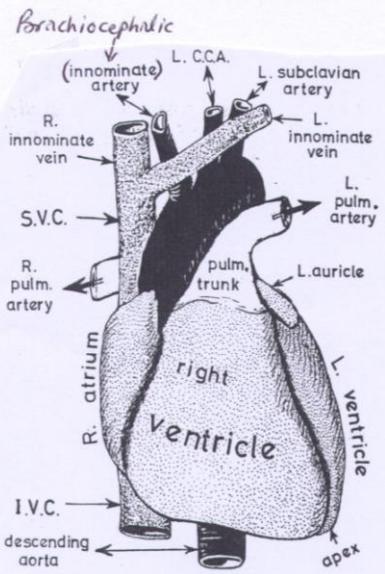


Fig.103 *Anterior view of the heart and the large vessels in the thorax.*

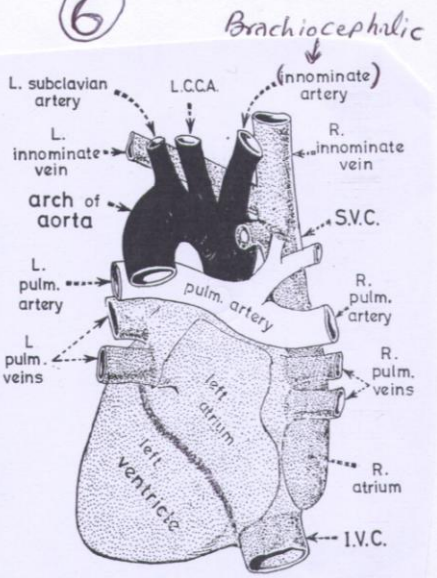


Fig.104 *Posterior view of the heart and the large vessels in the thorax.*

THE RIGHT AND LEFT VENTRICLES

"Externally", the 2 ventricles are separated from each other by the "*anterior*" & "*inferior*" **interventricular sulci.**

"Internally" the 2 ventricles are separated from each other by an *interventricular septum.*

The margins of the interventricular septum are indicated on the surface by the anterior and the inferior interventricular grooves. (sulci).

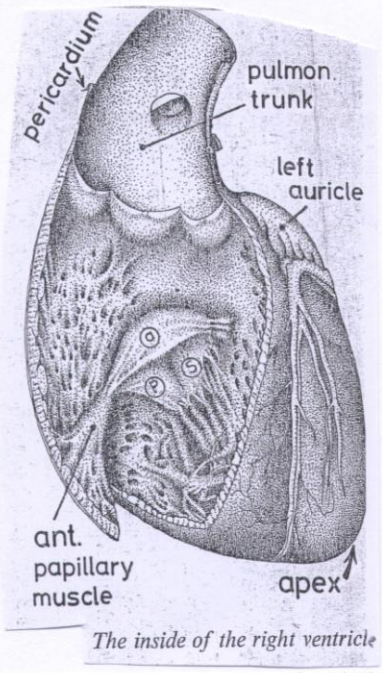
The *interventricular septum* lies obliquely so that one of its surfaces looks "*forwards and to the right*", the other surface looks "*backwards and to the left*". *The septum is convex to the right.* It is a strong **musculo-membranous partition:** the main part of it is muscular; only its upper and posterior part is membranous and is very thin. The "muscular" and the "membranous" parts have different embryological origins.

The walls of the ventricles are "rough" and sponge-like because they contain many coarse muscular bundles called **trabeculae carneae.**

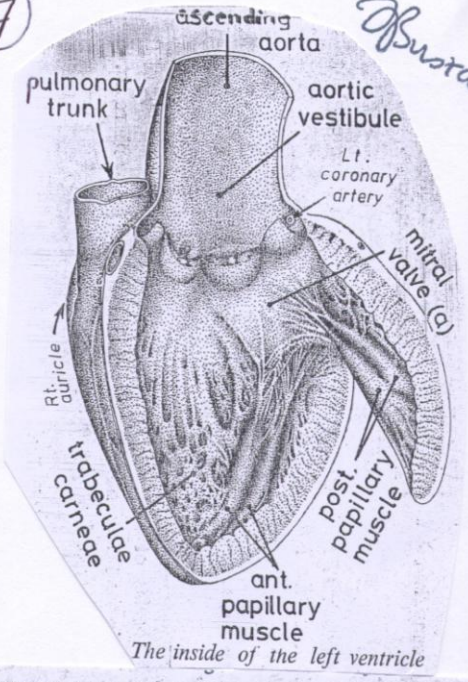
Papillary muscles (3 *in the Rt. ventricle* and 2 *in the Lt. ventricle*) project into the ventricular cavity. The apex of each papillary muscle gives attachment to delicate tendinous cords called **chordae tendineae;** which *resemble the* **"cords"** *of a "parachute"* whose other ends are attached to the borders and ventricular surfaces of the cusps of the A - V valves (tricuspid and mitral); *the* **cusps** *resemble the* **"silk"** *of the "parachute".*

The contraction of the papillary muscles makes the chordae tendineae tense and this prevents the cusps from being turned "inside out" as an umbrella would do in a windy day.

Right VENTRICLE	Left VENTRICLE
* forms 2/3 of the sternocostal surface.	* forms 1/3 in the sternocostal surface.
* forms 1/3 of the diaphragmatic surface.	* forms 2/3 in the diaphragmatic surface.
* forms nearly the whole "lower border" of the heart.	* forms nearly the whole "left border" of the heart; **also forms the "apex"** of the heart.
* semilunar in cross section (because the ventricular septum is convex to the right).	* circular in cross section.
* has thinner wall (because it pushes blood only to the lungs).	* has thicker wall (because it pushes blood to all parts of the body).
* has few and rough trabeculae carneae.	* has many fine trabeculae carneae.
* moderator band is present.	* No moderator band.
* has 3 papillary muscles [anterior, posterior & septal]	* has 2 papillary muscles [anterior posterior]



The inside of the right ventricle



The inside of the left ventricle

* The upper and anterior part of the Rt. ventricle is called the **"infundibulum"** and leads to the pulmonary trunk.
* The upper and anterior part of the Lt. ventricle is called the **"aortic vestibule"** because it leads to the aorta.
* The walls of the atria are about 3 mm. thick. The wall of the right ventricle is 3 times as thick as the walls of the atria.
* The wall of the left ventricle is 3 times as thick as the wall of the right ventricle.
* The **moderator band** is a bundle of muscle which stretches from the ventricular septum to the anterior wall of the **right** ventricle.
* The left ventricle has the shape of an egg with its wide end cut away and its pointed narrow end forming the **"apex"** of the heart.
* *The* **Rt.** *ventricle contains* **3** *papillary muscles :* (1) **anterior** (large) attached to the anterior wall. (2) **posterior** (or inferior) attached to the inferior wall. (3) **septal** (a group of small muscles attached to the interventricular septum).
* *The* **Lt.** *ventricle contains* 2 *papillary muscles:* **anterior & posterior;** they are larger than those in the Rt. ventricle.

	True	False
1-At the time of birth the walls of right and Left ventricle are of equal thickness	*	
2- The left ventricle is a high pressure pump While the right ventricle is a low pressure pump		
3- Repair of VSD may result in complete heart block		
4- part of the interventricular septum is Atrioventricular	*	
5- The interventriular septum lies in the sagittal plane		
6- The only function of the moderator band is The prevent overdistension of the right ventricle		*
7- concentric hypertrophy of the left ventricle could Be seen in a chronic hypertensive patient		
8- The infundibulum and the aortic vestibule Have the same embryonic origin		

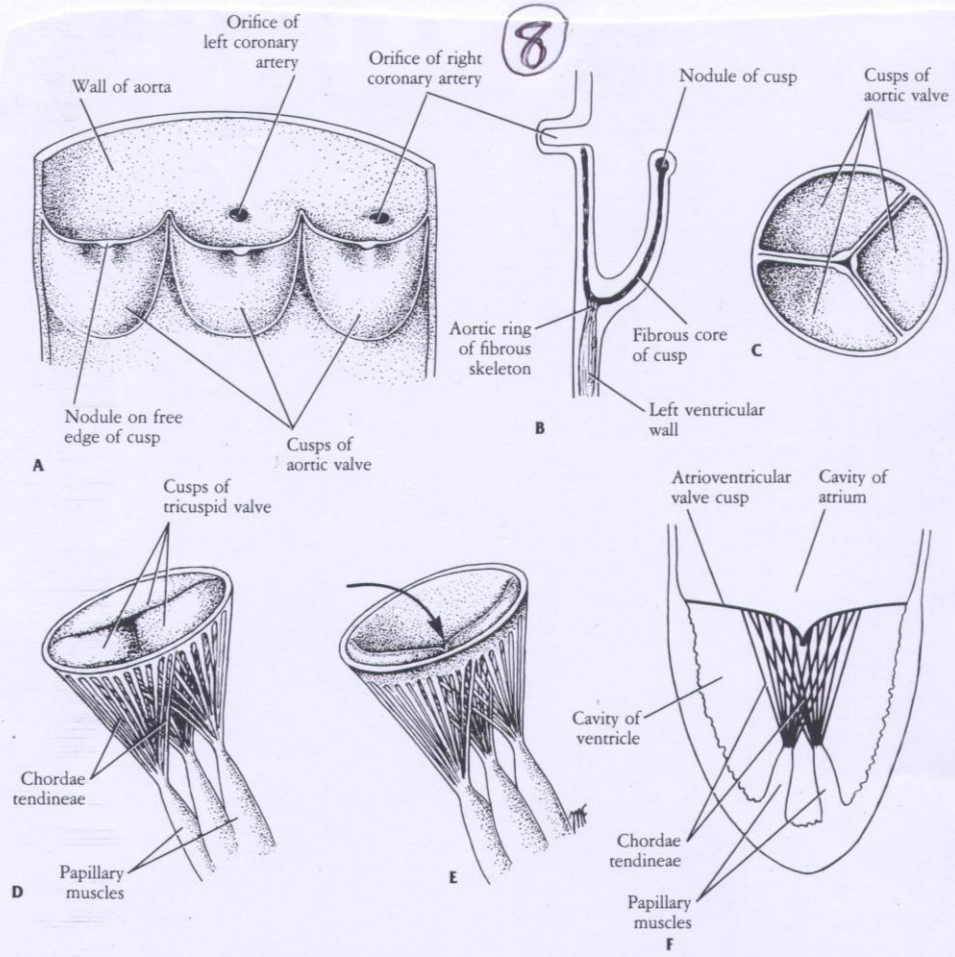


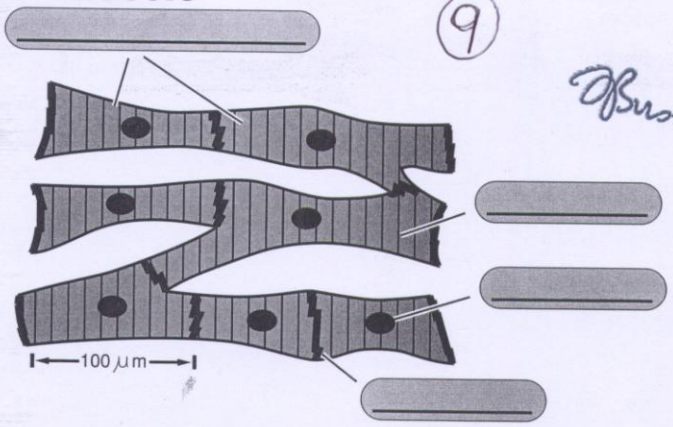
Fig. 8-6. A: Attachment of the cusps of the aortic valve to the wall of the aorta; B: section of a cusp of the aortic valve; C: superior view of the cusps of the aortic valve with the valve in the closed position; D: cusps of the tricuspid valve in the closed position; E: cusps of the tricuspid valve in the open position; F: section of atrioventricular valve, showing the attachment of the chordae tendineae to the cusps

- **How the Atrio –ventricular valves open and how they close.**
- **What contribute to the heart sounds? Opening or closure of these valves**
- **How the semi lunar valves open and how the close?**
- **Do the papillary muscles open or close the A- V valves?**
- **Opening of the aortic valves may limit coronary blood flow (comment)**
- **Ischemic rupture of a papillary muscle is expected to result in incompetent AV valve (true / false)**

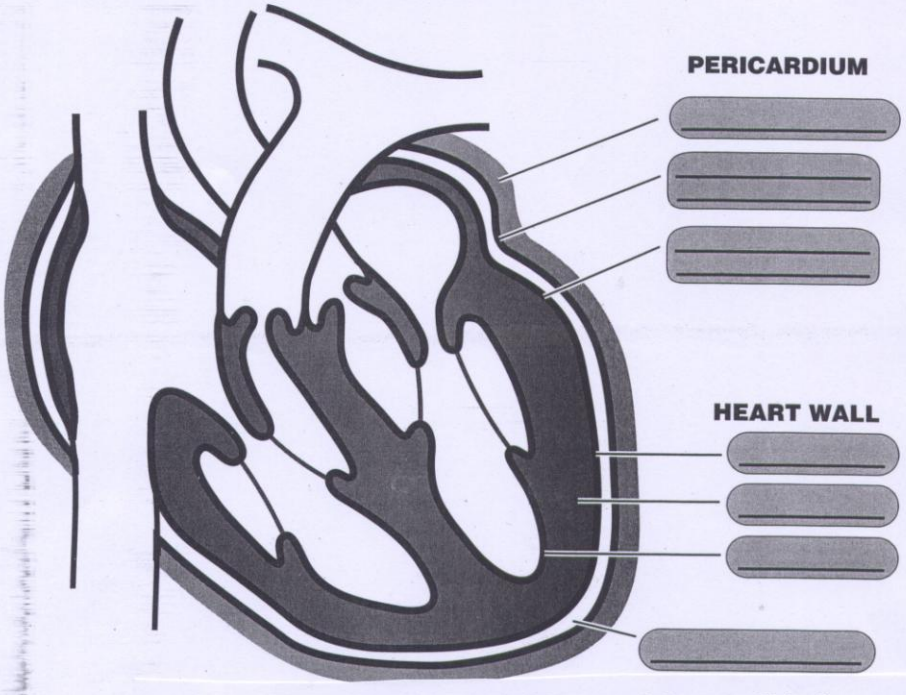
TISSUES

- the cardiac muscle represent a functional syncitium. comment
- what is the gap junction ?

Cardiac Muscle



Pericardium and Heart Wall



- Is pericarditis a painful or a painless condition?
- What is the volume of fluid that can accumulate within the pericardial cavity without causing cardiac tamponade?

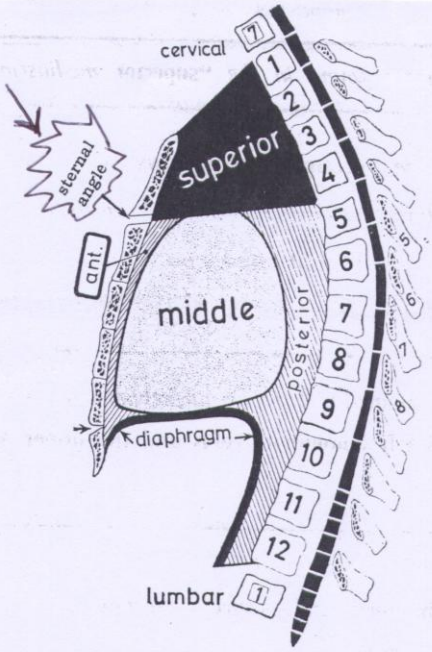


Fig. 98 *Boundaries and divisions of the mediastinum* (Midsagittal Section)

Variations of the positions of the mediastinum "in life".

1. The **position of the mediastinum** varies according to the **"position of the diaphragm"**.

   The diaphragm *descends during inspiration* - and because the pericardium is attached to the diaphragm, it (the pericardium) also descends "taking the **heart** with it"; *the* **trachea** *also descends during inspiration.*

2. The **position of the mediastinum** varies according to the **"position of the body"** as a whole :

* When you change from the "*supine*" to the "*erect*" position, the **mediastinum descends due to the pull of "gravity".** The reverse will occur i.e. the mediastinum will ascend when the abdomen is distended e.g. from pregnancy, a large liver, a full stomach .....etc.

The Sternal angle is a very important landmark. Comment ----------

I *Structures found in the* "middle" *mediastinum*

1. **The HEART**
2. **The ascending aorta and the pulmonary trunk.**
3. **The lower ½ of S.V.C. & the upper part of I.V.C.**
4. **Very small parts of the 4 pulmonary veins.**

} *inside the pericardium*

5. Transverse & oblique Sinuses
6. **The phrenic nerves** . . . . . (*outside the pericardium*)

III *Structures found in the* "posterior" *mediastinum*

(A) *Longitudinal structurrs:*

1. **The oesophagus.**
2. **The descending aorta.**
3. **The azygos & hemiazygos veins**
4. **The thoracic duct**

(B) "*Transverse*" *structures ;*

1. The *posterior intercostal arteries*
2. Certain *posterior intercostal veins.*

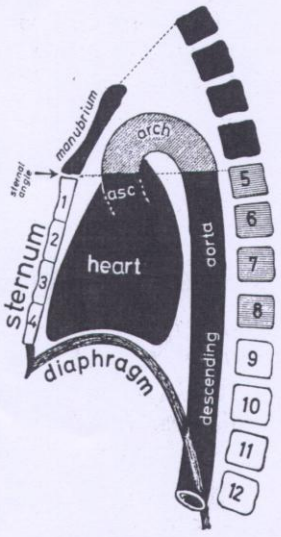


Fig. 99

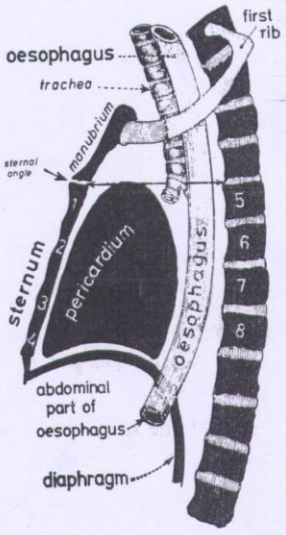
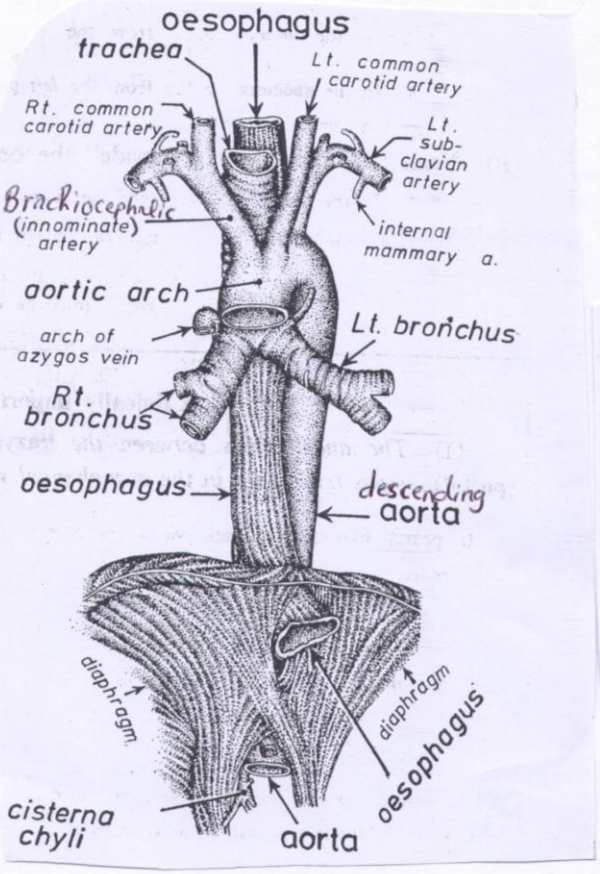
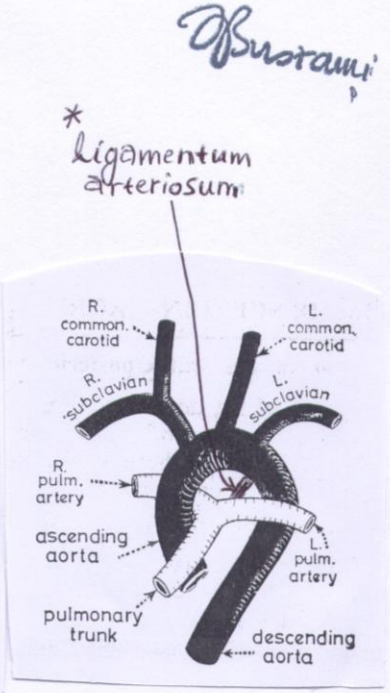


Fig.100

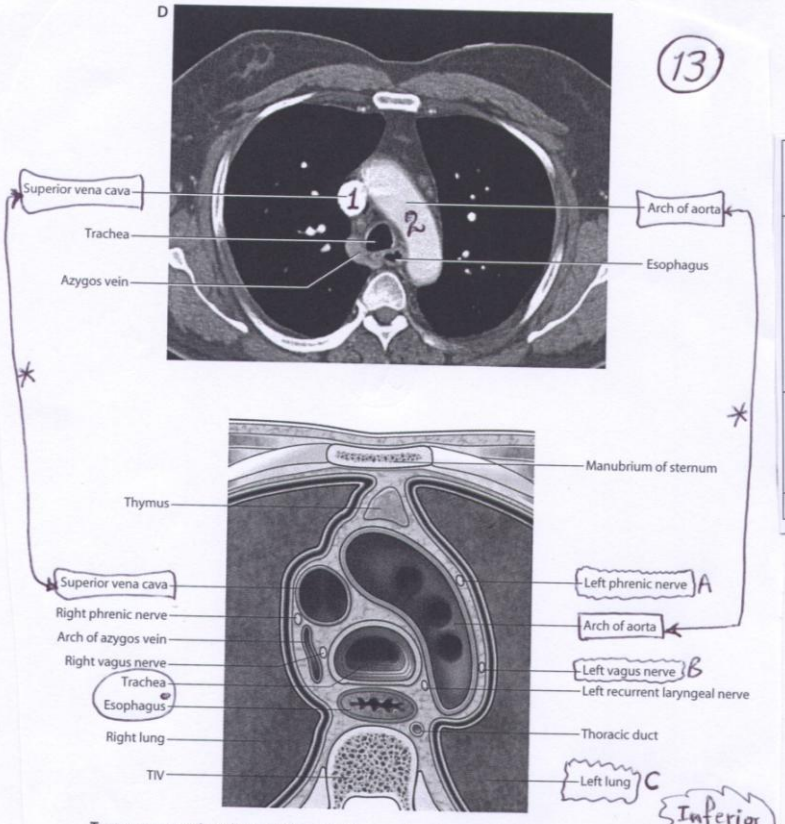
Fig. 99. (a) *The heart & the ascending aorta lie in the middle mediastinum.*
(b) *The arch of the aorta lies in the superior mediastinum.*
(c) *The descending aorta lies in the posterior mediastinum.*

Fig. 100 (a) *The heart lies in the pericardium in the "middle" mediastinum.*
(b) *The lower part of the "trachea" lies in the "superior" mediastinum.*
(c) *The oesophagus lies partly in the "superior" and partly in the "posterior" mediastinum.*



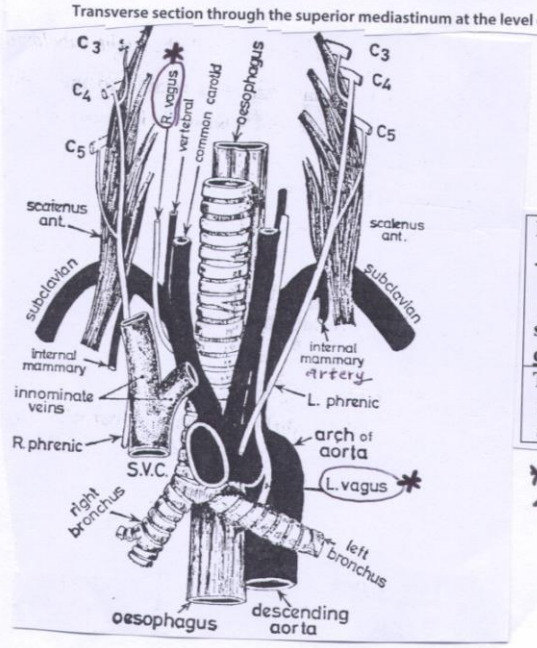


- **In the above diagram notice the following structures <u>Posterior to the pericardium (and Heart)</u> i.e within the <u>posterior mediastinum</u>:-**
  - **a. two major bronchi.**
  - **b. descending thoracic aorta.**
  - **c. oesophagus**
- **The <u>left bronchus</u> runs downward and to the left <u>anterior to the oesophagus</u>? <u>significance</u>?? (Remember the anatomical narrowing in the lumen of the oesophagus).**
- **Inferior to the aortic arch is the left bronchus and the right pulmonary artery.**
- **The ligament arteriosum runs between the beginning of the left pulmonary artery and the end of the aortic arch (In the embryo it was the ductus arteriosus)**
- **Remember above the aortic arch its 3 branches crossed anteriorly by the left innominate vein.**



Transverse section through the superior mediastinum at the level of vertebra TIV

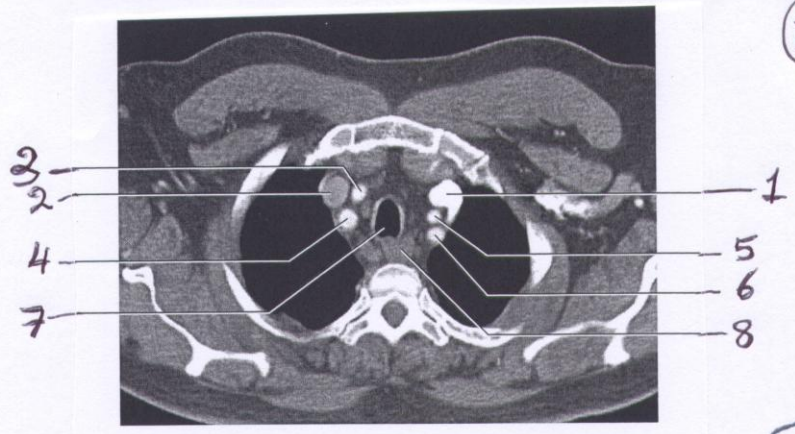
Which is more compliant 1 or 2?
Which of these two structures (1 and 2) can convert an intermittent flow of blood coming out of the heart into a continuous one?
Note the direction of structure 2 from before backward



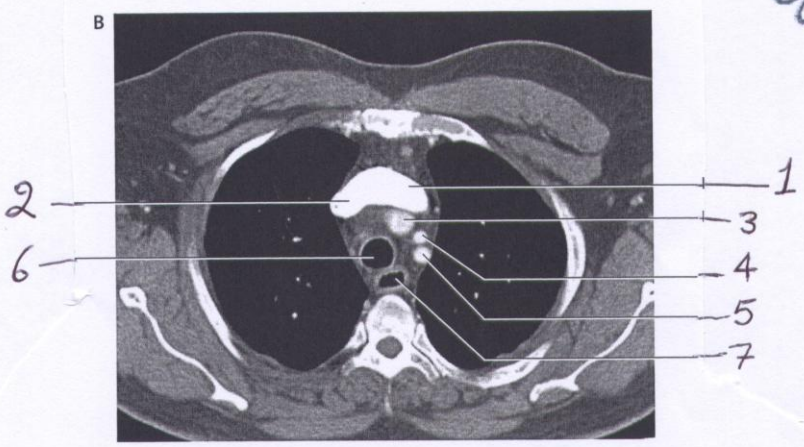
Remember :- Superficial to the aortic arch: left phrenic and left vagus nerves. In addition to cervical sympathetic and parasym pathetic nerves. All these structures are covered by the left lung - deep to aoric arch
Trachea and esophagus and the left recurrent laryngeal nerve in between, in addition to thoracic duct.

* Rt. & Lt. vagus Nerves have different course ???

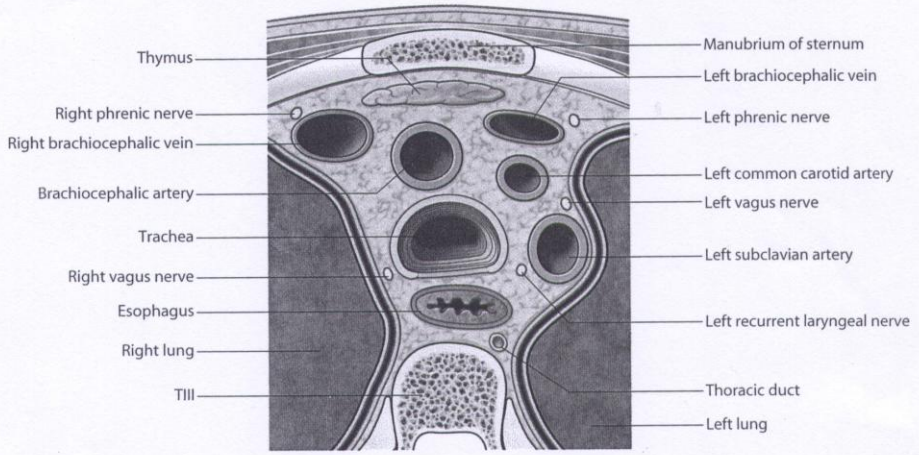
(14)



B

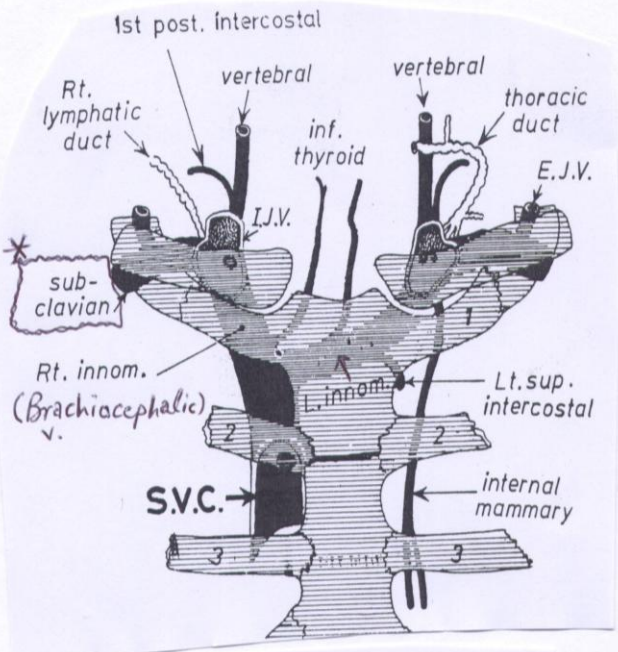


A through I – This is a series of images that pass through the thorax from superior to inferior showing the various mediastinal structures and their relationships with each other.
CT images, with contrast, in axial plane



Transverse section through the superior mediastinum at the level of vertebra TIII

* Name the Pointed Structures in the above two CT scans



15

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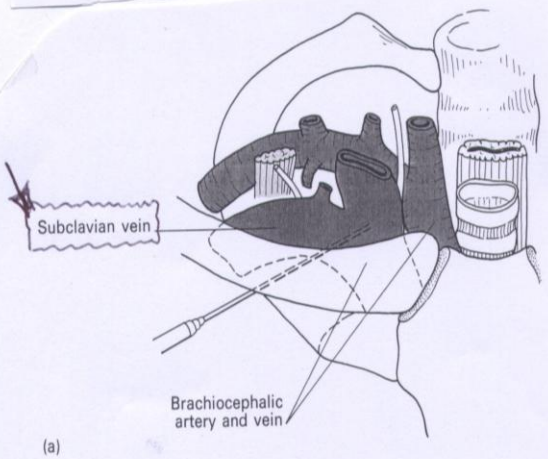
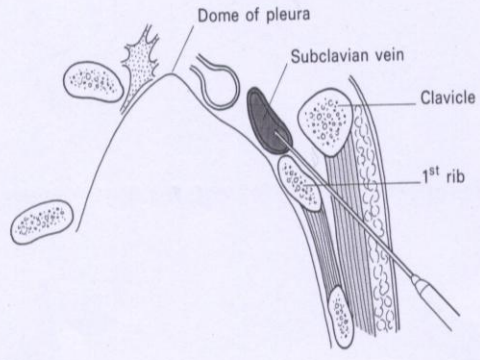
Remember :- the brachiocephalic (innominate) vein is formed posterior To the sternoclavicular joint by the union of the internal jugular and the subclavian veins, the superior vena cava is formed by the Union of the right and left brachiocephalic veins at the lower border of the right first costal cartilage near the sternum.





Techniques of central venous catheterization are now of great clinical importance both to measure central venous pressure (c.v.p), for practical purposes the pressure within the right atrium , and also to allow rapid blood replacement and long- term intravenous feeding by means of glucose, amino acids and fats. The internal jugular vein can be cannulated by direct puncture in the triangular gap between the sternal and clavicular heads of the sterno- mastoid immediately above the clavicle. The needle is inserted near the apex of this triangle at an angle of 30-40° to the skin surface and is advanced caudally towards the inner border of the anterior end of the first rib behind the clavicle. A reflux of blood confirms venepuncture. Subclavian venepuncture can be carried out most effectively by the infraclavicular approach (Fig218). The needle is inserted below the clavicle of the junction of its medial and middle thirds. The needle is advanced medially and upwards behind the clavicle in the direction of the sterno-clavicular joint to

* At its origin (from the left ventricle) the wall of the ascending aorta is dilated to form 3 swellings called the "**aortic sinuses**" (one anterior & two posterior).
* *The* **"right"** *coronary artery arises from the* **"anterior"** *aortic sinus.*
* *The* **"left"** *coronary artery arises from the* **"left posterior"** *aortic sinus.*
* After the two coronary arteries arise from the ascending aorta, they swing forwards one on each side of the pulmonary trunk; each coronary artery being protected in this area by its corresponding auricle.

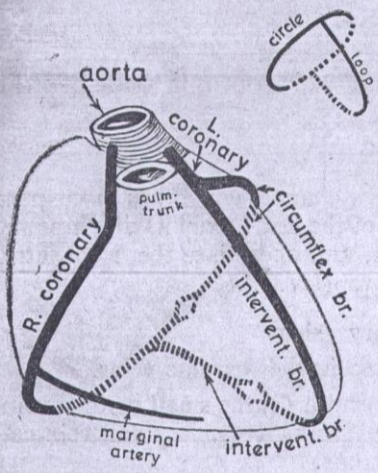


Fig. 123 *The right and left coronary arteries and their branches form a* "**circle**" *and a* "**loop**".

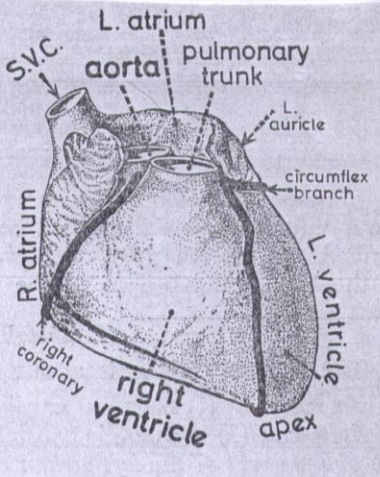


Fig. 124 *The sterno-costal surface of the heart and the right and left coronary arteries.*

The left coronary artery

* Arises from the **"left" posterior** *aortic sinus* and runs forwards between the root of the pulmonary trunk and the left auricle to reach the upper end of the anterior interventricular groove where it divides into two branches:
(a) an **interventricular** branch and (b) a **circumflex** branch.

(a) The **inter-ventricular** *branch* (which is sometines called the **anterior interventricular artery**) descends in the "*anterior*" *interventricular groove* to reach the inferior border of the heart near the apex; here it turns round the sharp inferior border to reach the "*inferior*" *interventricular groove* and *ends there by anastomosing with the* **interventricular branch of the right coronary** *artery.*

(b) The **circumflex** *branch* runs to the left in the A-V groove, turns round the left border of the heart and *ends by anastomosing with the* **right coronary** artery.

Branches : Two main branches [*and small unnamed branches*]

1. *A* **cricumflex** *branch.*
2. *An* **interventricular** *branch* (called the **anterior** *interventricular artery*).
3. *Many small unnamed branches.*

(17)

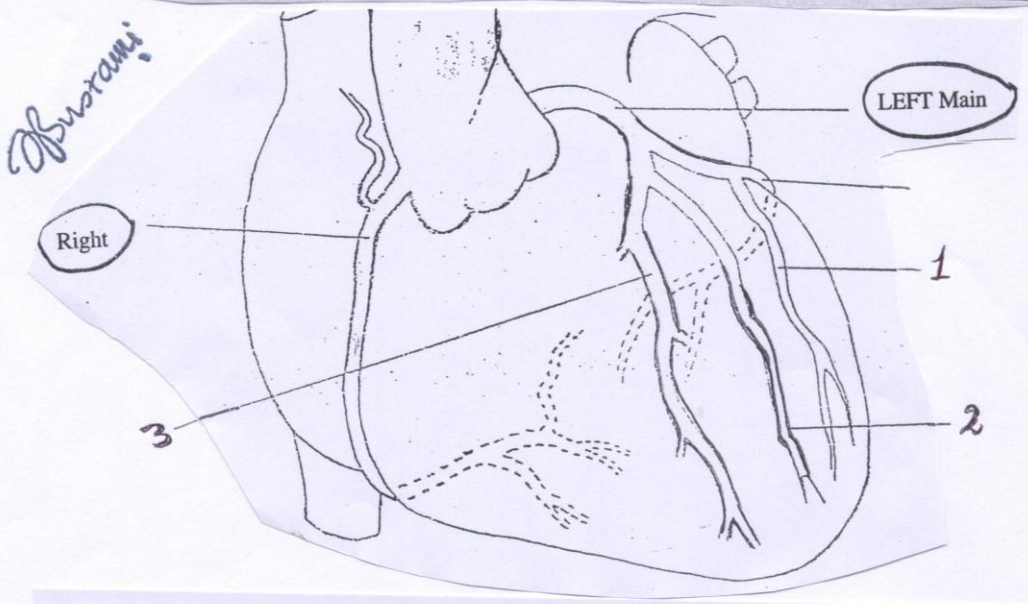
The right coronary artery

* Arises from the "**anterior**" *aortic sinus* and runs between the root of the pulmonary turnk and the right auricle to reach the A-V (coronary) groove on the anterior surface. *In this groove it passes downwards and to the right till the junction of the "right" and "lower" borders of the heart.*
* Here it gives its **marginal** branch (which runs *along the lower border of the heart*).
* The right coronary then turns "backwards" to run in the part of the A-V (coronary) groove which separates the posterior surface from the inferior surface of the heart and *ends here by anastomosing with the "circumflex" branch of the left coronary artery.*
* Before it ends by anastomosing with the circumflex branch of the left coronary, the right coronary artery gives its **interventricular** branch which descends forwards in the inferior interventricular groove and ends by anastomosing with the interventricular branch of the Rt. coronary aartery.

Branches : Two main branches [*and small unnamed branches*] :

1. *A* **marginal** *branch* : which runs along the lower margin of the anterior surface. This branch is sometimes called the **marginal artery.**
2. *An* **interventricular** *branch* : called **inferior** (or posterior) interventricular *artery.*
3. *Small unnamed branches supply the roots of the arota and pulmonary trunk.....etc.*

Abstract



- **Name the numbered branches1.2.3.**
- **Coronary blood flow is affected by the pressure in the ascending aorta as well as by intraventricular pressure. Accordingly during ventricular systole blood flow will decrease more in the right or left coronary artery?**
- **If CAD affects LAD → ischemic necrosis will affect which part of the heart**

Regulation of Coronary Blood Flow

The coronary arterioles contain both alpha and beta adrenergic receptors, which promote vasoconstriction and vasodilation, respectively. Norepinephrine released by sympathetic nerve fibers stimulates alpha-adrenergic receptors to raise vascular resistance at rest. Epinephrine released by the adrenal medulla can stimulate the beta-adrenergic receptors to produce vasodilation when the sympathoadrenal system is activated during the fight-or-flight reaction.

Most of the vasodilation that occurs during exercise, however, is due to intrinsic metabolic control mechanisms. The intrinsic mechanisms occur as follows: (1) as the metabolism of the myocardium increases, there are local accumulations of carbon dioxide, K^+, and adenosine in the tissue, together with depletion of oxygen; (2) these localized changes act directly on the vascular smooth muscle to cause relaxation and vasodilation.

Under abnormal conditions blood flow to the myocardium may be inadequate, resulting in myocardial ischemia (chapter 13). The inadequate flow may be due to blockage by atheromas and/or blood clots or to muscular spasm of a coronary artery (fig. 14.17). Occlusion of a coronary artery can be visualized by inserting a catheter (plastic tube) into a brachial or femoral artery all the way to the opening of the coronary arteries in the aorta and then injecting a radiographic contrast material. The picture thus obtained is called an **angiogram.**

In a technique called **balloon angioplasty,** an inflatable balloon is used to open the coronary arteries. However, *restenosis* (recurrence of narrowing) often occurs. For this reason, a cylindrical support called a **stent** may be inserted to help keep the artery open. If the occlusion is sufficiently great, a **coronary bypass** may be performed. In this procedure, a length of blood vessel, usually taken from the saphenous vein in the leg, is sutured to the aorta and to the coronary artery at a location beyond the site of the occlusion (fig. 14.18).

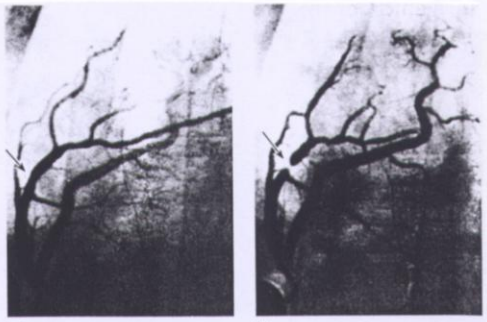


Figure 14.17 **Angiograms of the left coronary artery of a heart patient.** These angiograms were taken *(a)* when the patient's ECG was normal and *(b)* when the ECG showed evidence of myocardial ischemia.

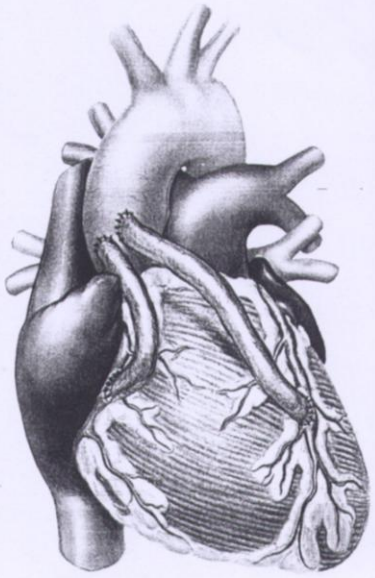
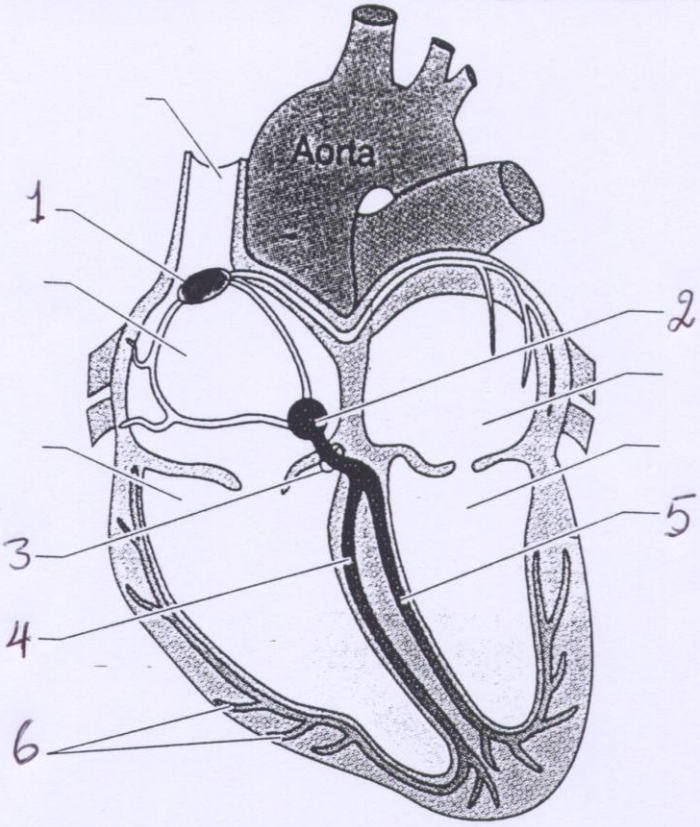


Figure 14.18 **A diagram of coronary artery bypass surgery.** Segments of the saphenous vein of the patient are commonly used as coronary bypass vessels.

What is the King of grafts ??

- **Remember that the cardiac muscle is composed of contractile and conducting muscle fibres.**
- **Name the pointed structures (1-5)**
- **The right coronary artery supplies blood to all (1.2.3.4.5) Except part of 5 (true/ false)**
- **Surgical repair of a VSD may damage one of the following (1.2.3.4.5) and results in ……..**



Bustami

- **Structure 6 has faster conduction than the atria or structure 1 (true / false)**

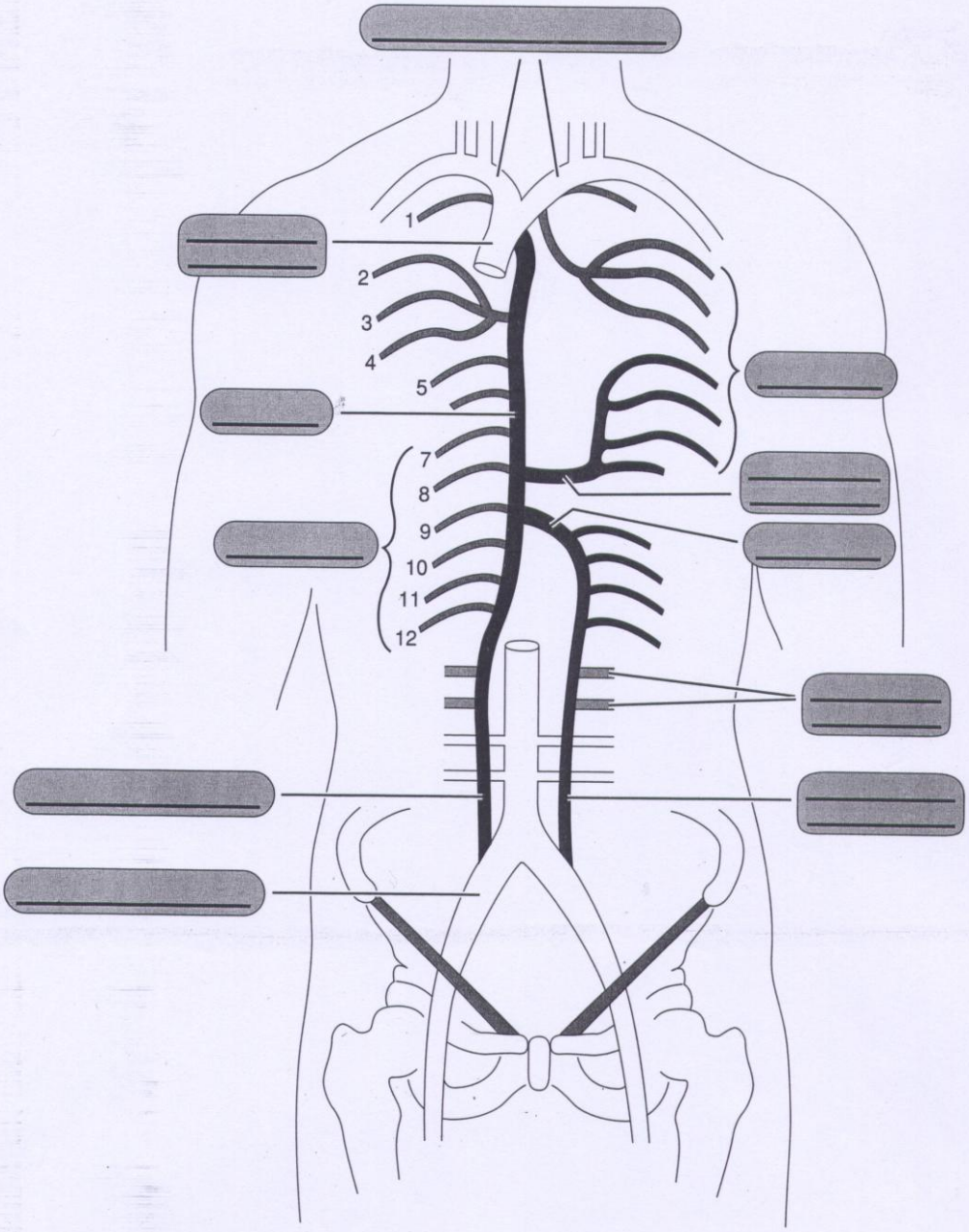
Conduction velocity

- **Atria →1 m/ sec**
- **Av node → 0.01 -0.05 m/sec**
- **Purkinje fibre → 2-4 m /sec**
- **Sympathetic supply to the heart reaches 1.2.3.4.5.6 while the parasympathetic reaches only 1 and 2 (true / false)**
- **2.3.5.6 can act as <u>latent pacemakers</u> (true / false)**

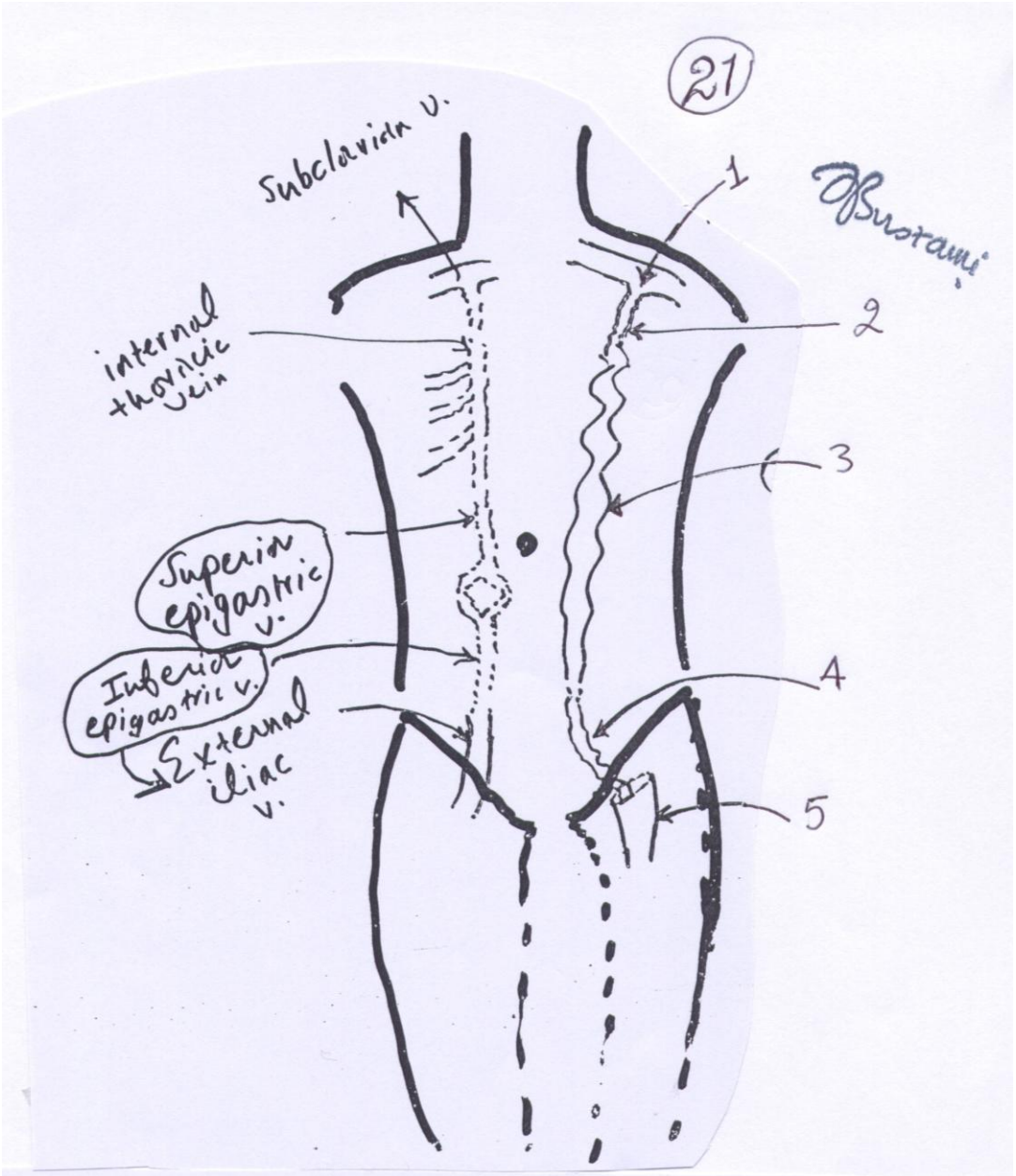
VEINS : Azygos System

(20)

Bustami



- **Name the pointed vessels.**
- **How the azygos vein begins?? And where does it end?**
- **The azygos vein collects blood from the thoracic and upper abdominal walls (true/ false)**

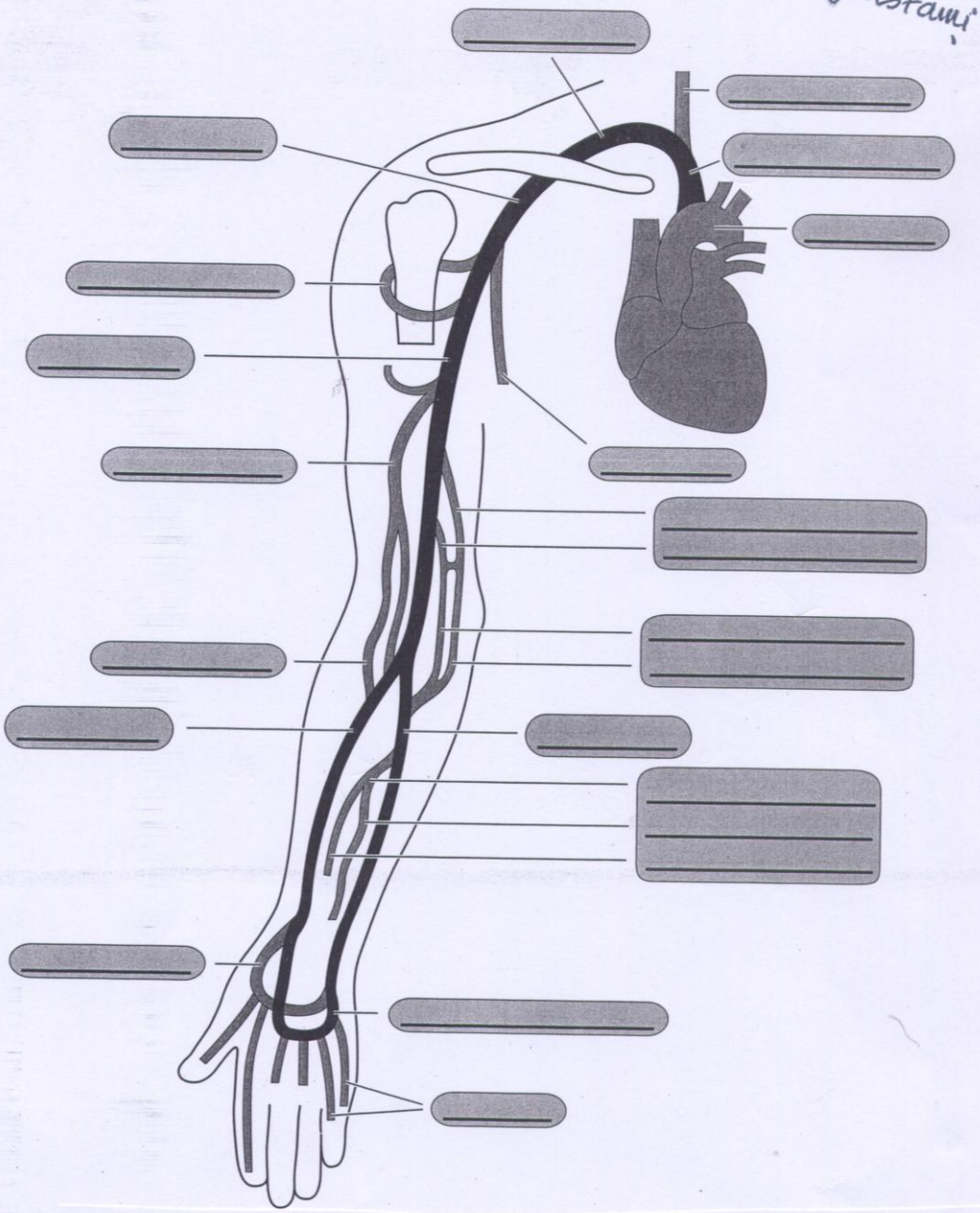


- **Name the pointed vessels 1.2.3.4.5**
- **The collateral circulations in the above diagram appears following obstruction of ……**
- **Direction of blood flow in structure 3 determines the blood vessel obstructed? Comment……**
- **What is the nearest organ to IVC?**

ARTERIES : Right Upper Extremity

22

Bustami

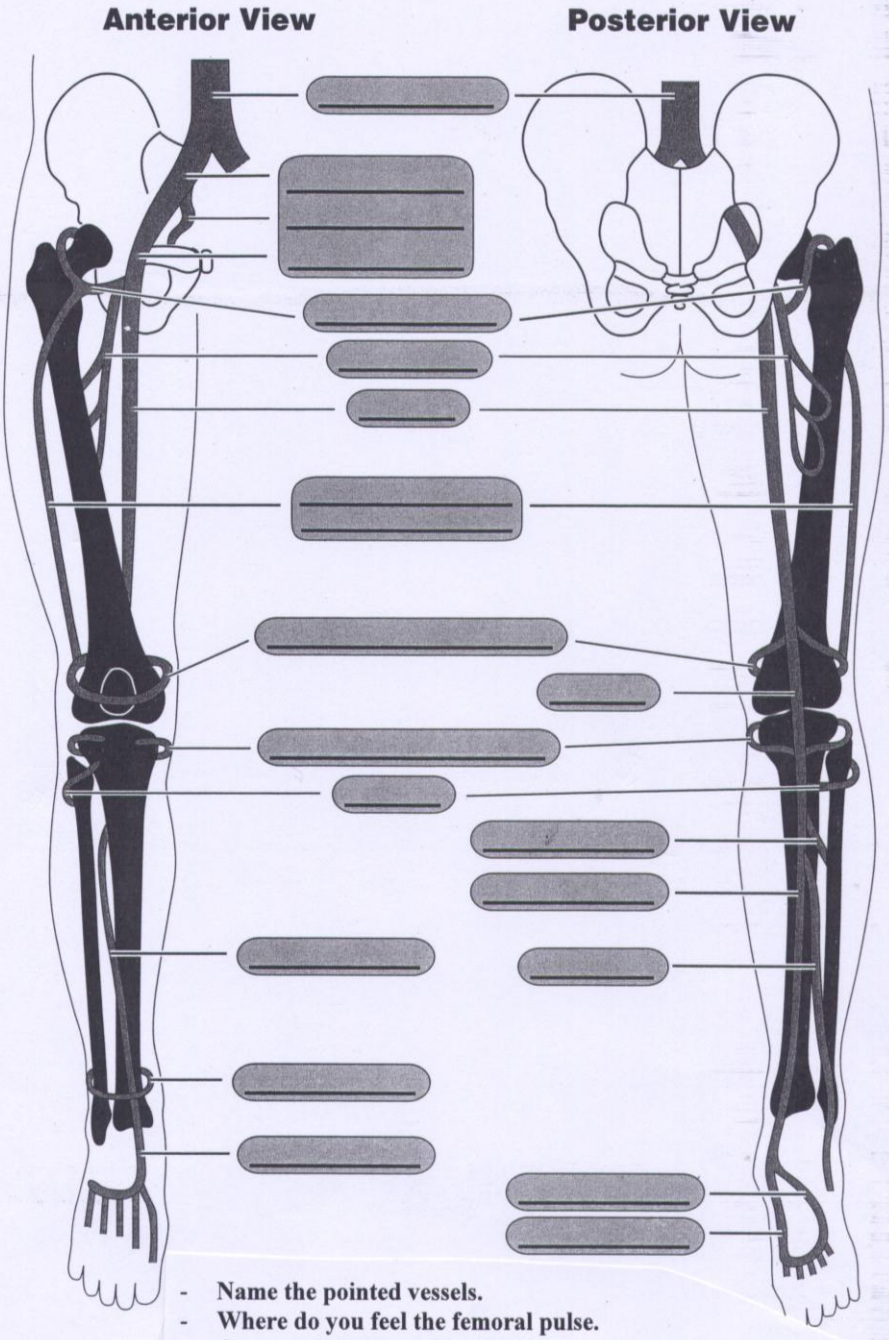


- Name the pointed vessels
- Where do you feel the pulse in arteries of the upper limb
- In supracondylar fracture of the humerus, an artery may suffer compression or damage??
- What is Volkmans ischemic contracture?

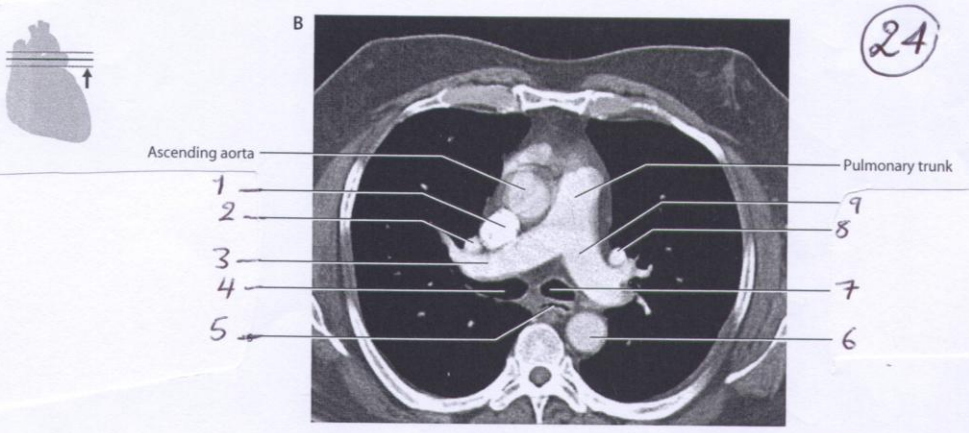
ARTERIES : Lower Extremity

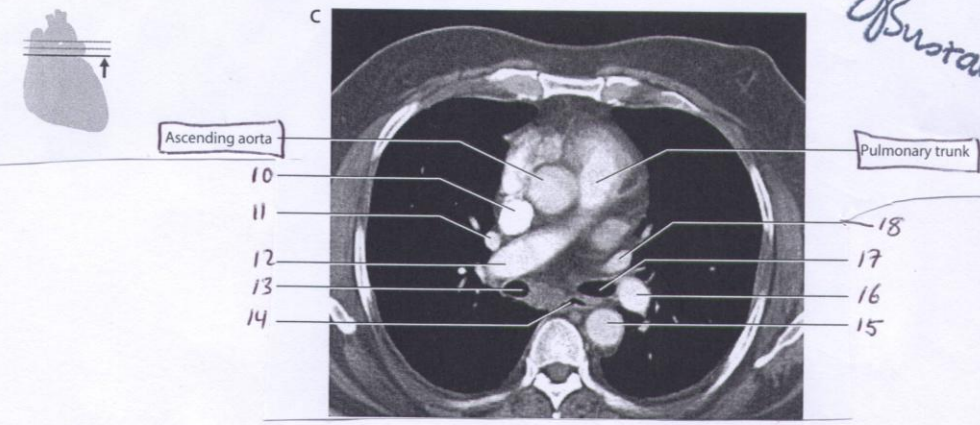
23

Bustami



- Name the pointed vessels.
- Where do you feel the femoral pulse.
- Can you feel the popliteal pulse.
- Absent dorsalis pedis pulse means an ischemic foot (true/ fales)





(In the above CT images : Name structures 1–18)

The pulmonary trunk and **the ascending aorta**

General

* The pulmonary trunk and the ascending aorta lie within the fibrous pericardium *behind the first (uppermost) piece of the body of the sternum.*

* The two vessels lie within a common sheath of serous pericardiun and behind them lies the transverse pericardial sinus. (What is the truncus arteriosus

* The upper parts of the 2 atria, their auricles& the S.V.C.«embrace»the pulmonary trunk and the ascending aorta from behind but fail to meet in front of them. Here (in front) these two vessels are coverd by the pericardium, the pleurae and the lungs.

* The **pulmonary trunk** is two inches (5 cm) long; it *arises from the right ventricle behind the sternal end of the "left third" costal cartilage.*

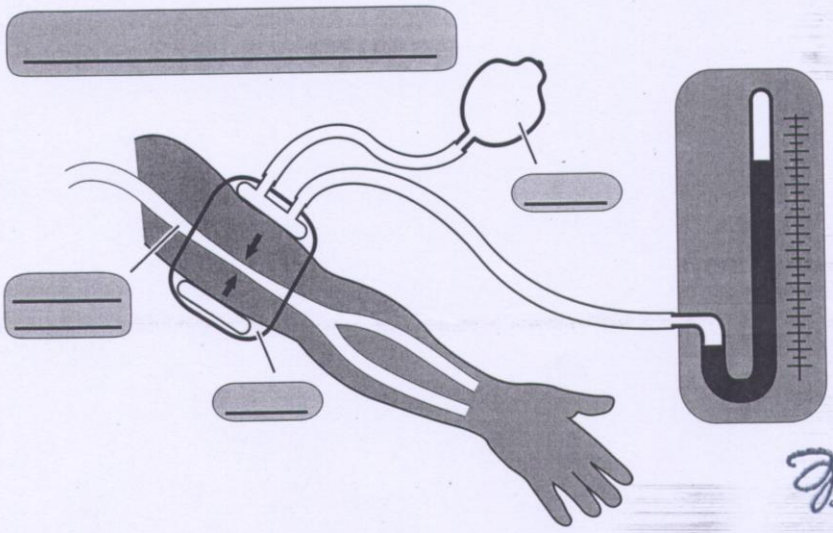
It begins in front of the arota and runs *upwards* and *backwards* and to the *left* (winding around the left side of the ascending aorta) until it reaches the concavity of the aortic arch where it *ends by dividing into the right and left pulmonary arteries.*

* The stems of the right and left coronary arteries pass (from the ascending aorta) forwards on either side of the root of the pulmonary trunk.

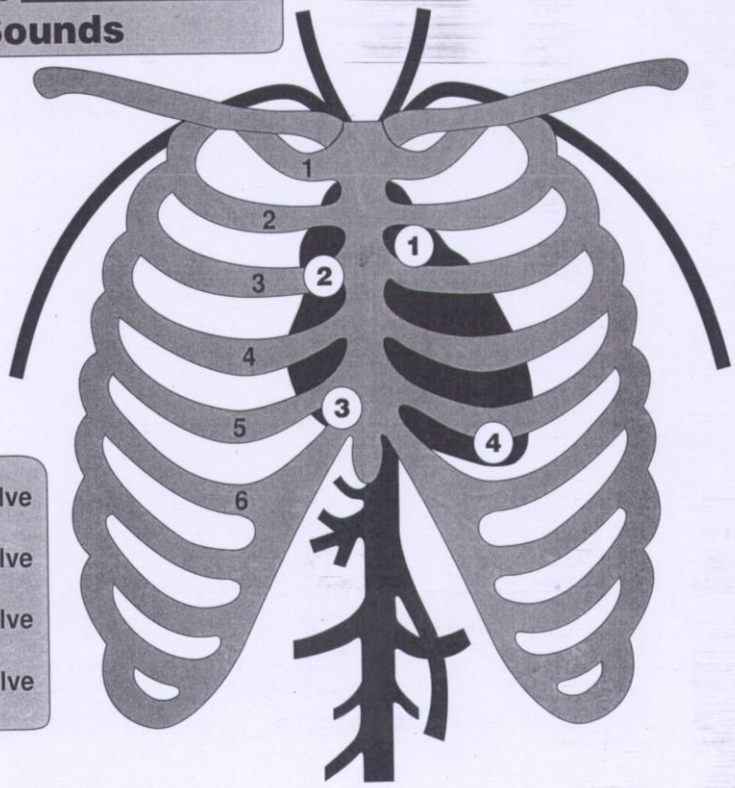
* The right and left pulmonary arteries lie along the upper borders of the right and left atria and of the upper pulmonary veins like the transverse piece of the letter "T".

25

MEASUREMENT OF BLOOD PRESSURE



Location of _____ for Valve Sounds



1. _____ Valve
2. _____ Valve
3. _____ Valve
4. _____ Valve