

Human Anatomy & Embryology

Lecture: Coronary circulation & Blood vessels

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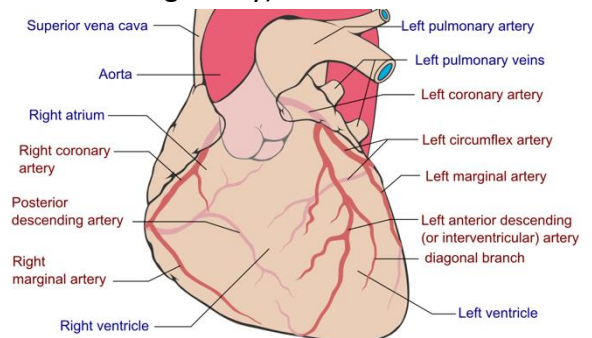
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Coronary circulation

- Heart is a muscular organ and needs a good blood supply (Arterial and venous systems).
- Arterial coronary system is made of two main arteries (coming from the very beginning of the ascending aorta):

1. Right coronary artery:

- Found in the coronary sulcus, which is a groove/depression between the atria and ventricles.
- Right coronary artery gives small branches to supply right atrium and right ventricle as they run in grooves, also gives a very important little branch to SA node (pacemaker).
- While it runs in coronary sulcus, it gives a branch that goes down along with the inferior border of the heart, this branch is called **marginal branch (Artery)** (recognized by running along the lower/inferior border of the heart made by right ventricle).
- Right coronary artery then curves posteriorly where it is still in the coronary sulcus till it reaches the posterior interventricular sulcus the coronary artery ends up and becomes **posterior interventricular artery** (*continuation; not a branch*).
- Right coronary artery is long and originates from the anterior right aortic sinus (deep to the pulmonary trunk and right auricle) → runs in coronary sulcus (and gives branches for right and left ventricles and SA node here) for long distance till it reaches the posterior interventricular sulcus where it ends and become posterior interventricular artery (posterior descending artery).
- Posterior interventricular supplies → wall of both ventricles (posteriorly) and posterior part of the interventricular septum.
P.S: the doctor said that the posterior interventricular artery is not always and necessarily to be a branch/continuation of the right coronary artery.



2. Left coronary artery:

- (from anterior left aortic sinus, deep and posterior to the pulmonary trunk and the left auricle – lift the left auricle to observe it clearly).
- Short (1 cm long- left main trunk) and soon divides (after 1cm) and gives two main branches:

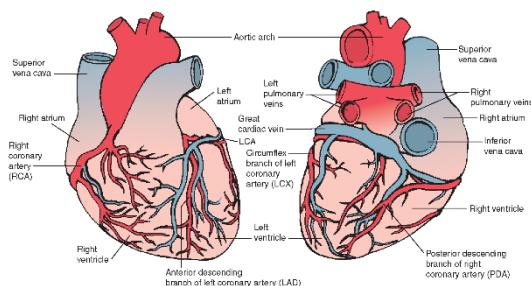
A. Anterior interventricular artery: (AKA left anterior descending artery):

Runs in the anterior interventricular groove reach the apex of the heart and then turns posteriorly.

- Supplies structures from right and left → right and left ventricles (anteriorly), and deep into the interventricular septum.
- Anterior and posterior interventricular arteries may or may not anastomose (connect) (NOT must connect).
- It also gives a **diagonal branch** that supplies the left ventricle.

B. Circumflex artery: (travels through circumflex of the heart).

- Is a continuation of left coronary artery.
- Runs in the coronary sulcus and ends in the posterior aspect of the heart where it meets the posterior interventricular artery (the continuation of right coronary artery).
- Supplies → left atrium and left ventricle.



▪ Venous coronary system that drains blood from the heart muscle:

1. Great cardiac vein:

- I. In the anterior interventricular sulcus.
- II. Runs along with the anterior interventricular artery (AKA left anterior descending artery).

2. Middle cardiac vein:

- I. In posterior interventricular sulcus between the left ventricle and right ventricle
- II. Runs along with the posterior interventricular artery.
- III. Joins small cardiac vein in the coronary sulcus, between the right ventricle and right atrium to form coronary sinus.
- IV. Drain → posterior wall of ventricles and posterior interventricular septum.

3. Anterior cardiac vein:

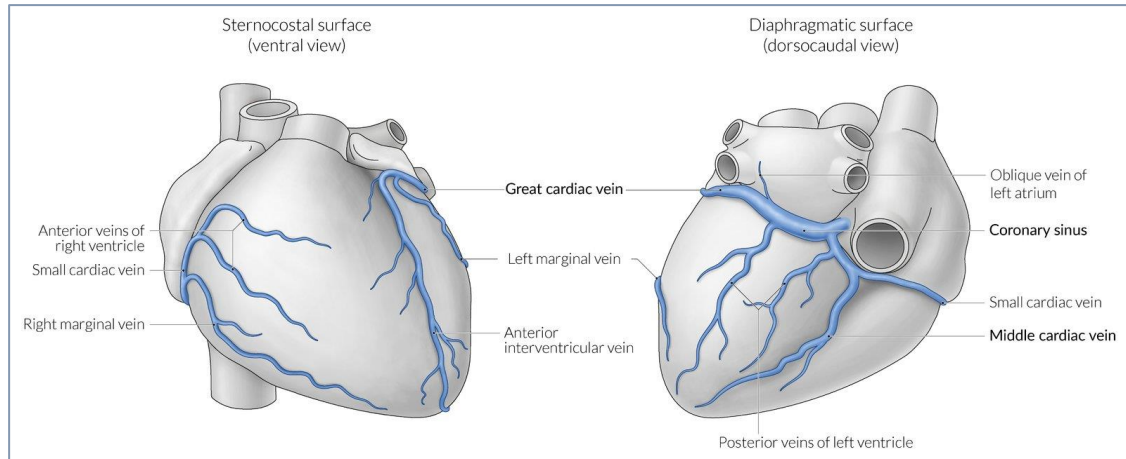
- I. In coronary sulcus (between the atrium and the ventricle).

4. Small cardiac vein:

- I. In coronary sulcus between right atrium and right ventricle.
- II. Run along with the marginal artery.
- III. Drain → the right ventricle on the lateral side.

5. Coronary sinus:

- I. Is the collection of all the above veins → creating a large vein (coronary sinus), thin wall and has no smooth muscles.
- II. In the Posterior coronary sulcus between left atrium and left ventricle.
- III. Drains into the right atrium along with inferior and superior venae cavae.

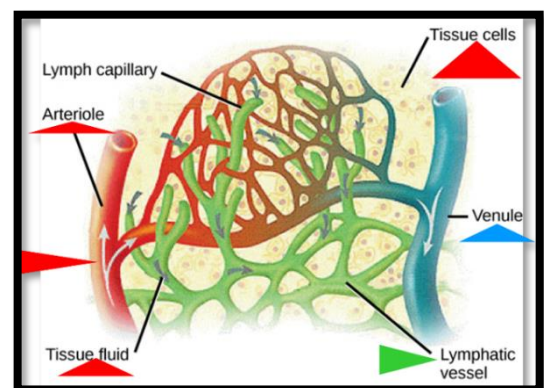
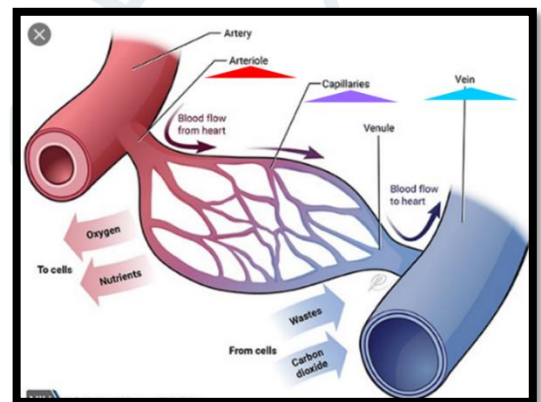


Blood vessels: arteries

The last part of the arterial system is the arteriole >> feed the capillaries (lies between cells of the tissues) >> blood goes to the veins with: less oxygen, less nutrients, more waste material

this is our target consist of the following parts:

- 1) **Arteriole:** the smallest artery. it is the last part of the arterial system.
- 2) **Tissue fluid:** contain oxygen and nutrients.
- 3) **Tissue cells:** immersed in tissue fluid. Tissue cells take what they need and leave what they don't need.
- 4) **Venule:** the very beginning part of the venous system
 - capillary pick up the wastes and send it to the venules.



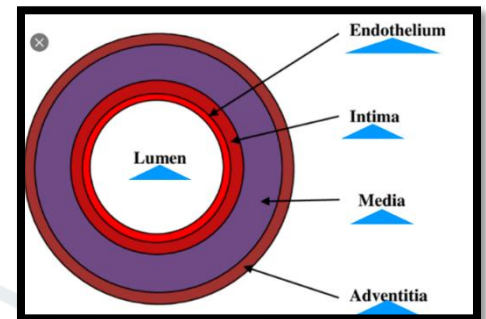
- capillaries the smallest part of the vascular system – they are found between tissue cells:
 - 1- arterial side > deliver the oxygen and nutrients from arterioles.
 - 2- venous side > take the waste product to venules.
 - here, there is a continuity between arterial side and venous side, unlike in the heart where they're totally separated from each other.

5) lymphatic vessels: if there is foreign bodies or large molecules which veins cannot pickup, the lymphatic capillaries -having gaps- can pickup large particles (like large bacteria or pathogens) and send them back to the venous system.

cross section of blood vessel (artery)

it has the following:

- 1) **lumen:** spaces where the blood flows in
- 2) **endothelium:** which blood meets very smooth surface (must be very smooth so blood don't clot)
- 3) **internal and external elastic lamina**
- 4) **tunica intima:** loose areolar C.T – this layer encloses the flowing blood
- 5) **tunica media:** thickest layer and made of C.T or muscle or both
- 6) **tunica adventitia:** loose areolar C.T –attach arteries to the surrounding structures.



Structures of the arterial system:

1) Tunica intima

- ✓ Made of:
 - a. Endothelial cells – simple squamous cells
 - b. thin loose areolar connective tissue under endothelial cells (subendothelial C.T).
- ✓ Discontinuous elastic lamina (basement membrane).
- ✓ Intima means in close relation (to the blood).

2) Tunica media

- ✓ Can have elastic membranes (C.T).
- ✓ Can have smooth muscle cells.
- ✓ **Thickest layer** of a wall of an **artery**.

3) Tunica adventitia

- ✓ It is a thin layer of connective tissue.
- ✓ Fixes the artery to the surrounding structures.

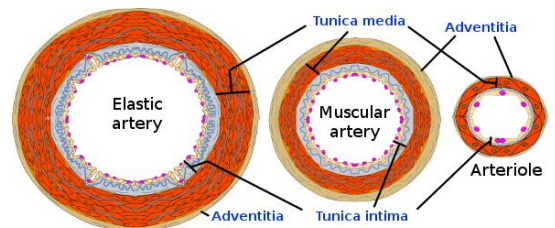
The arterial system:

- 1) **Large elastic (conducting) arteries:** have elastic C.T in their tunica media.
- 2) **Medium muscular (distributing) arteries:** have smooth muscle
- 3) **Arterioles** – reach the tissue cells
- 4) **Metarterioles** – supply capillary beds and they have > (precapillary sphincters)

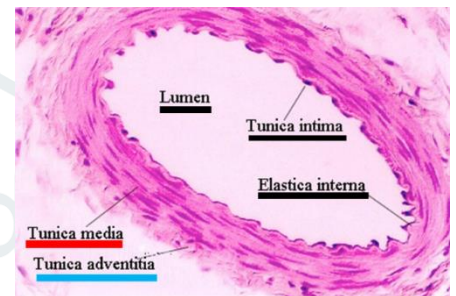
If this sphincter contract >> less blood getting into the capillary >> blood pressure rises in arteries

- 5) **Capillaries** – the smallest part

- ✓ when the elastic (conducting) arteries get smaller -go further from the heart- they become muscular (distributing) arteries.
- ✓ elastic arteries, muscular arteries, and arterioles, all of them have three layers in their walls.

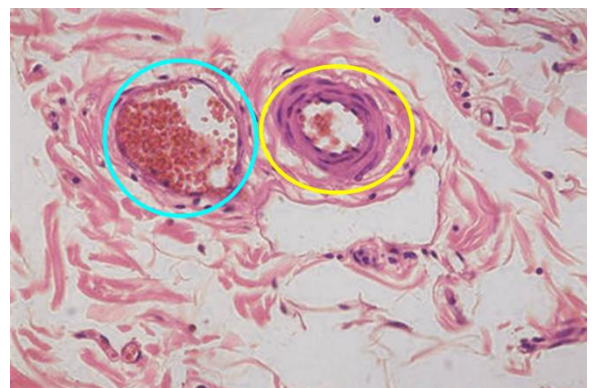


- ✚ The same story here but the difference is this image is cross section of the artery under the microscope



At the right (artery):

- When we get down to the smaller and smaller of the arteries, we get to the stage of small artery at the beginning of the arterioles where you can see:
 - lumen filled with blood
 - endothelium
 - 2 layers of smooth muscle
 - Little adventitia around
 - thick wall



At the left (vein):

- Larger lumen
- Thinner wall

Capillaries:

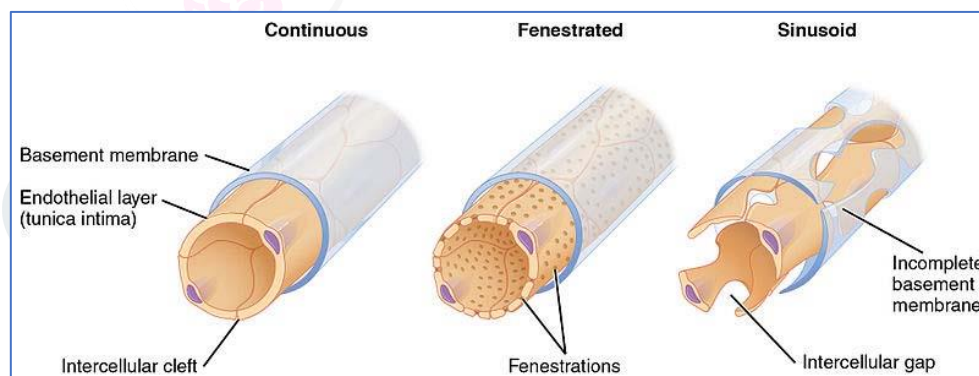
- ✓ Smallest artery
- ✓ Made up only by the inner layer (endothelium) then basement membrane; No media, no adventitia.
- ✓ We find capillaries at the end of the arterial system (between cells of tissue)
- ✓ Why single layer? Things can go in and out easily (by diffusion)
- ✓ Not all types of tissues have the same type of capillary it differs according to the organ and to the function.
- ✓ Types of capillary:

1) Continuous: endothelial cells have intercellular clefts, so they're connected directly together and there's no gaps between them.

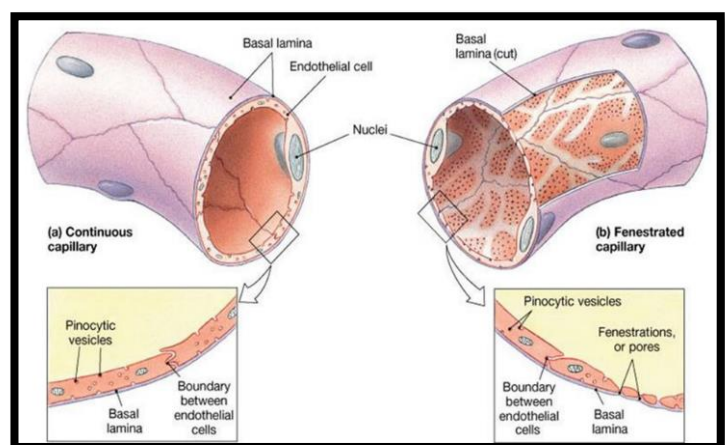
2) Fenestrated: found in kidneys, have small pores (**fenestrations**) through endothelial cells themselves.

3) Sinusoid: found in the liver, has LARGER LUMEN, and has large gaps in:

- basement membrane (also called basal lamina), and thus > it is not a complete membrane.
- endothelial cells (gaps is between cells (intercellular gaps), not through a cell itself like in fenestrated capillary type).

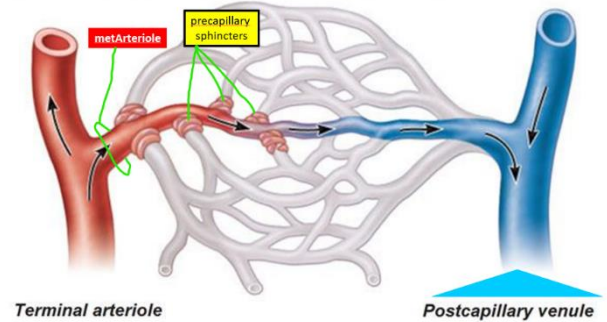


Study this figure:



- last part of arterial system, which is terminal arterioles, when they want to make a capillary bed, they give a lateral branch called **metArteriole** that runs horizontally (as in the image. Not always horizontally) to open from the other end and drain into postcapillary venule. This metarteriole gives origin to the capillary bed, meaning that capillaries starting to grow from this transverse channel (metarteriole) and expand through the tissue desired to feed.

Capillary Beds – “Vascular Shunt”



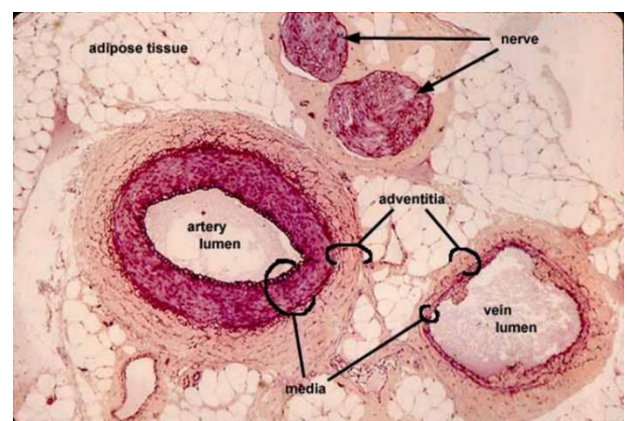
- since capillaries don't have smooth muscle layer (that is used to control blood amount allowed to flow inside the vessel); so we need an alternative structure.

- As we can see in the image, at the beginning of each capillary growing from metarteriole, we have **precapillary sphincters**: smooth muscle rings that is like a faucet (صنبور أو حنفية بالمشرمجي) to control blood flow from metarteriole to the capillary bed.

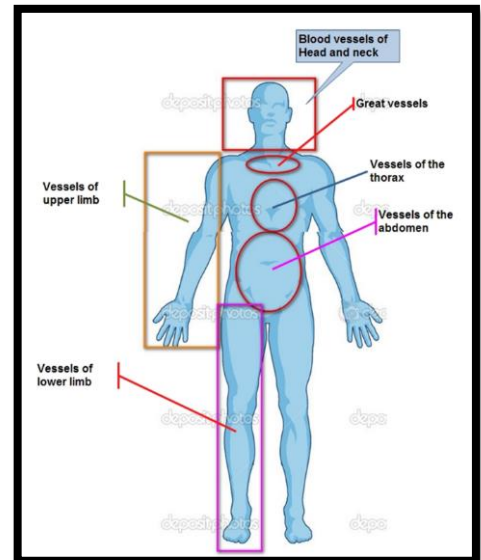
- When the precapillary sphincters are relaxed (open), blood flows into the capillaries; thus blood pressure in arterial system decreases.

- When precapillary sphincters contract (close or partially close), blood flow through the capillaries ceases or decreases; thus blood pressure in arterial system increases.

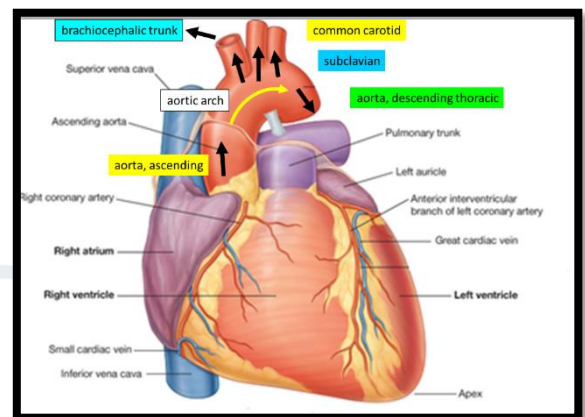
- ✚ Notice here the difference between the artery and the vein in the structure:



- Great vessels come out of the heart and then branch to feed different structures in upper and lower limbs, head and neck, thorax, abdomen.



- anterior view of the heart
- **aorta**: the largest artery in the body, comes from the left ventricle. Type: elastic artery.
- when the ventricle pushes the blood to the aorta, it expands and because its elastic it's going to come back and this add more force to the blood to come in (we mean come to the aorta)
- parts of aorta:



1) ascending aorta.

2) aortic arch, gives raise to 3 branches:

1. **brachiocephalic trunk** (or innominate meaning "not named yet") (right one): supply right upper limb, right side of head and neck.
2. **common carotid** (middle one) – supply the left side of head and neck
3. **subclavian** (left one) – runs under the clavicle – supply the left upper limb.

3) descending thoracic aorta

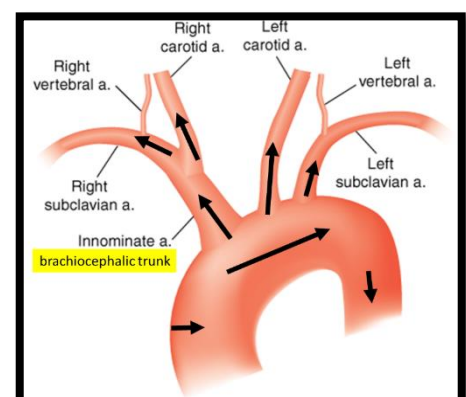
4) descending abdominal aorta

1. brachiocephalic trunk gives:

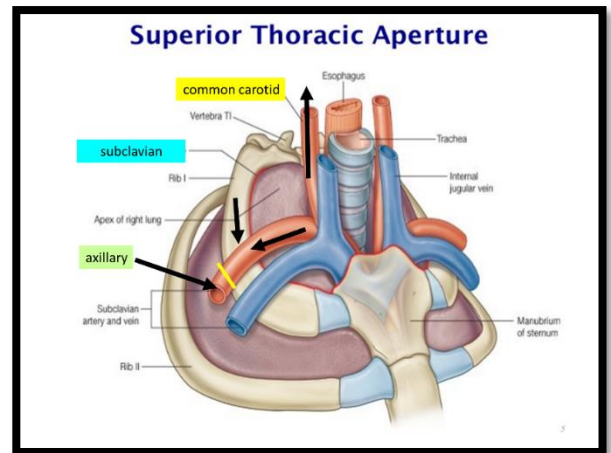
- 1) right subclavian artery
- 2) right common carotid artery

2. left common carotid (here common carotid comes from the arch itself because the arch of aorta is going to left)

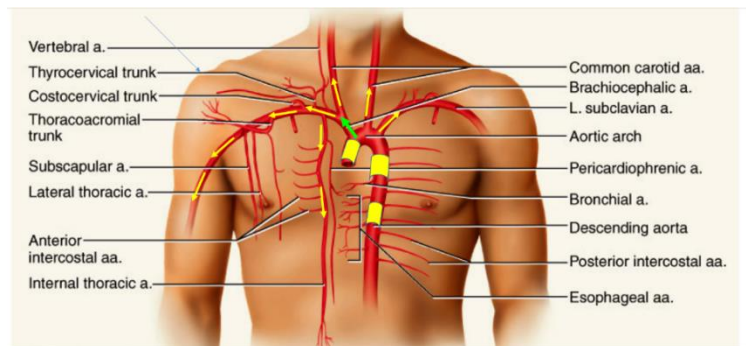
3. subclavian become left subclavian artery (the same story come from arch directly)



- ✦ subclavian artery goes to the upper limb therefore it travels on the top surface of the first rib (through subclavian groove of the first rib) and when it reach the lateral margin of the first rib >> its name become axillary artery (according to the new position). It does not branch, in continues as single artery, BUT; due to positional change (from subclavian area to axillary area) its name is changed from subclavian to axillary artery.

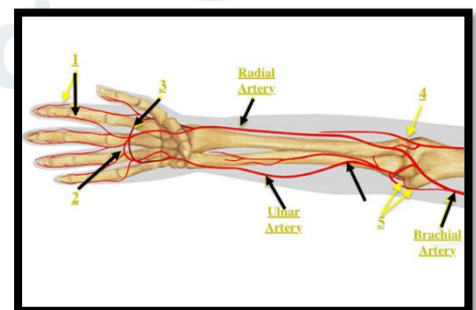


- Brachiocephalic trunk > subclavian artery > axillary artery > brachial artery.
- Left common carotid – arise directly and supply head and neck.
- Left subclavian – also arise directly from the arch, supply the upper limb.



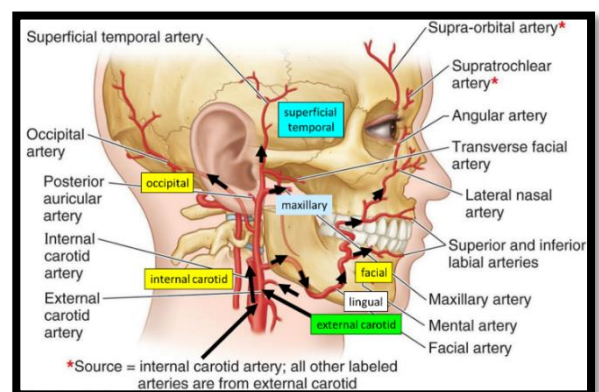
brachial artery divides into:

- 1) Ulnar artery (medially)
- 2) Radial artery (laterally) – most used in checking pulses at the wrist
 - These two arteries together make:
 - 1) Superficial arch in the palm of the hand
 - 2) Deep arch in the palm of the hand
 - From these arches arise the digital arteries to supply fingers until their tips.

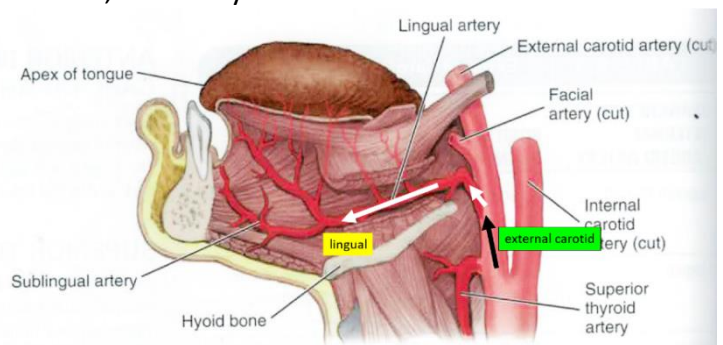


Common carotid divide into:

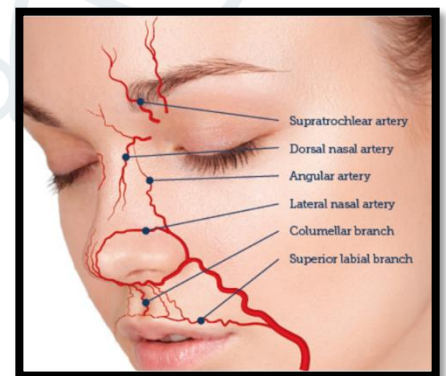
- 1) Internal carotid artery: enters the skull and supply the brain and the meninges (we're not concerned about it right now).
- 2) External carotid artery: supply face and skull



- One of the branches of external carotid artery (from its inferior part) is the **lingual artery**, which supplies the tongue. As it goes up, just behind the angle of mandible, to supply submandibular salivary gland, then it emerges from mandible to the face, it is called facial artery, when it go up towards the angle of the eye, it gives 2 branches to supply upper and lower lips: superior and inferior labial arteries respectively, and then it goes to the angle between eye and nose. All of this is the facial artery.
- we can notice that facial artery is tortuous, has many curves.
- On the external carotid artery, superior to the branchpoint of lingual artery, we have another branch called **maxillary artery** (inters the infratemporal fossa deep to ramus of mandible) >> gives many branches.
- The final (terminal) and most superior branch of external carotid artery is the **superficial temporal artery** which passes in front of the ear and supplies the superficial temporal area.
- On the posterior side of the external carotid artery, we have a branch called the **occipital artery** which passes posterior to the ear and goes to feed occipital area.
- External carotid artery also gives a deep branch to the pharynx (not shown in the image).

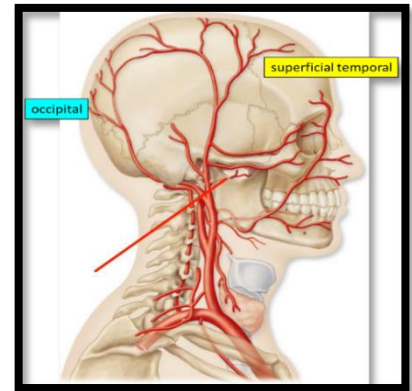


- ✚ In this image we can see that facial artery supplies superior lip and external part of nose.

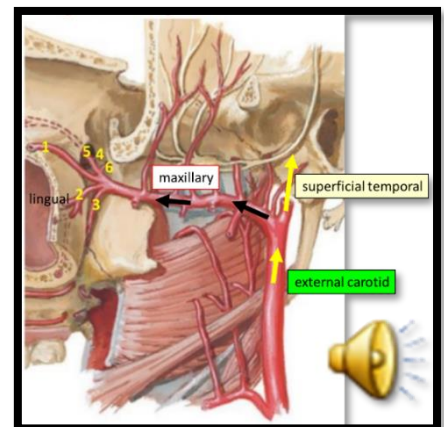


External carotid supply:

- Face
- Lateral part of the skull or scalp (فروة الرأس)
- Posterior part of the skull or scalp

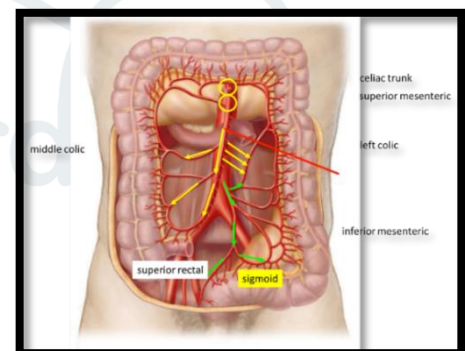


Maxillary artery after it enters infratemporal fossa it gives about 15 branches to feed infratemporal area and maxillary area.



Thoracic aorta ONLY gives **posterior intercostal arteries**.

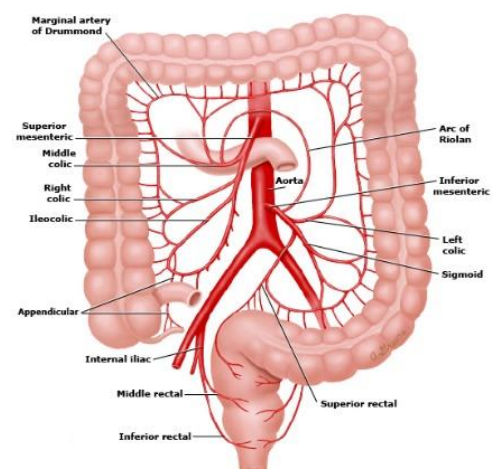
Abdominal aorta gives 3 anterior branches and lateral branches (a set on the right and a set on the left -pair-, while anterior branches are single ones).



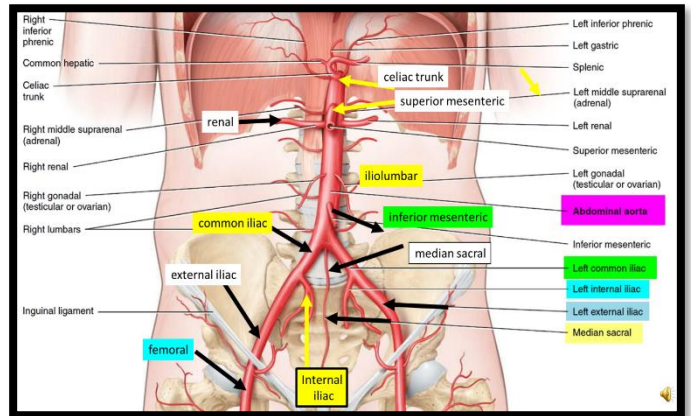
✚ superior mesenteric artery (single) > give several branches to the small intestine called (ilial branches) and then it gives ileocolic artery and middle colic artery to supply right part of large intestine (ascending colon).

✚ inferior mesenteric artery (anterior + a little bit to the left) to supply left part of large intestine (descending colon), and it branches to: left colic artery, sigmoid artery supplies sigmoid, and superior rectal artery supplies superior part of rectum.

- Abdominal aorta becomes abdominal when it passes underneath the median arcuate ligament of the diaphragm.



- **Celiac trunk** (single): supply the liver, spleen, stomach, diaphragm, part of the duodenum.
- **Superior mesenteric artery** (single, 1 or 2cm inferior to celiac trunk): runs in the mesentery of the small intestine. as it comes to the right iliac fossa, supply the ilium, jejunum, right side of the large intestine (cecum, ascending colon, part of transverse colon).
- **Renal arteries** (paired, comes slightly inferior to superior mesenteric artery): supply the two kidneys.
- **Iliolumbar arteries** (paired): supply the posterior abdominal wall.
- **Inferior mesenteric** (single): supply the left part of the colon, upper part of the rectum



- Aorta at level of L5 divides into:

1) Right Common iliac >> (called iliac because it comes over the ilium of hip bone) - Branches to **internal iliac** >> supply the structures inside the pelvis like uterus, ovaries, urinary bladder, rectum...

- Right common iliac Continue as **external iliac** – as it passes under the inguinal ligament and enters the anterior part of the thigh it becomes the **femoral artery**.

2) Left common iliac - the same branches above.

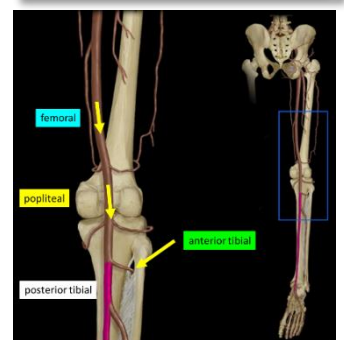
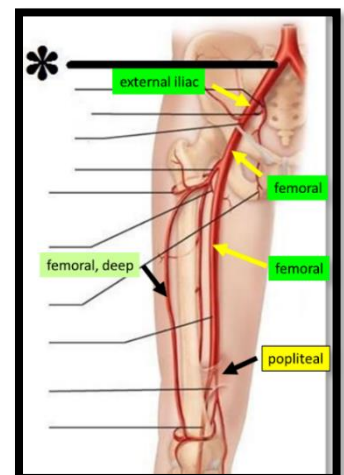
- femoral artery branches to:

a. deep femoral artery supplies hamstring muscles (posterior thigh group of muscles).

b. as femoral artery goes down near to the knee, it changes its position from anterior of femur >> to posterior of femur, then it enters the popliteal fossa; after this it is being called **popliteal artery**.

- ❖ femoral artery >> popliteal artery >> when it becomes posterior to the tibia it is called **posterior tibial artery**.

- ❖ near the upper end of the tibia there is branch of the popliteal artery goes to the anterior of the leg passing through a hole in the interosseus membrane, this branch is called **anterior tibial artery**.

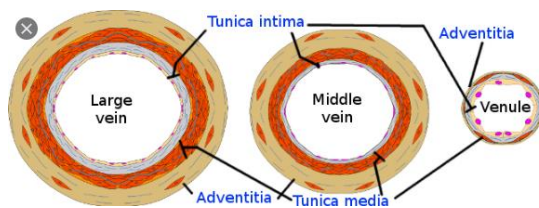
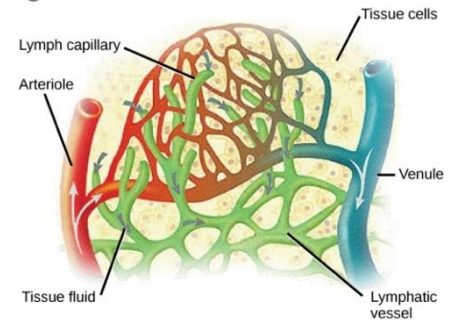


Blood vessels: Veins

Veinous system: return deoxygenated blood from the tissues to the heart then this blood will reoxygenated in the lungs and back to heart in oxygenated form.

Capillary beds: it's the end of arterial system (arterial side) and the begin of venous system (venous side)

- Blood will travel in this pathway: Arteriole (oxygenated) → capillary bed (diffusion) → venule (deoxygenated)
 - ✓ In the venule side, the vessels start increase in their size until reaching the heart.



We will discuss these layers later on

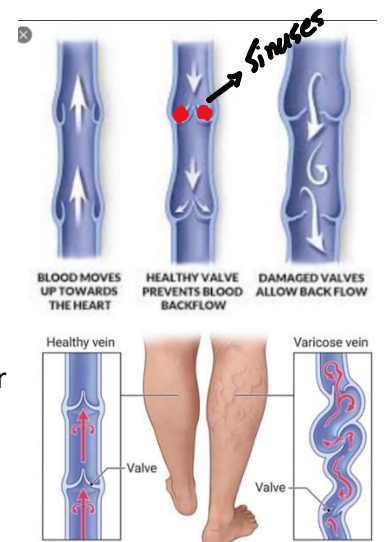
As we know, the left ventricle will pump the blood to all over the body but when this blood enters the venous system there is not any system to pump the blood from the veins back to the heart so how we can solve this problem?

- **Muscles:** when muscle contract, this contraction will compress the veins and pushes the blood toward the heart.
- **Valves:** prevent the backflow of the blood when muscles don't contract, make the blood in one way ☺
 - ✓ Valves are made of tunica intima.



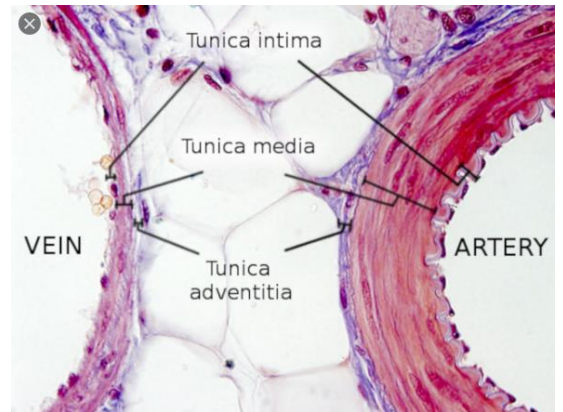
Open Valve
Allows blood to flow freely upwards during a muscle pump.

- ❖ Figure in the left, this situation happens when the muscles are contract.
- ❖ Figure in the middle, this situation happens when the muscles don't contract to prevent the backflow of the blood by filing the sinuses between the valves.
- ❖ Figure in the right, for some reason these valves don't functionally well so when muscle don't contract the blood will back this will lead to something called **Varicose vein**.
 - ✓ In **Varicose vein:** the veins will dilate in increase in their size.

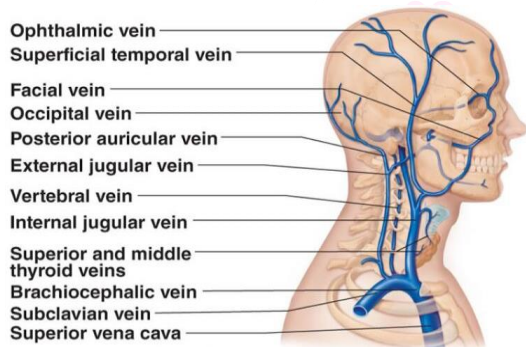


Histology of veins:

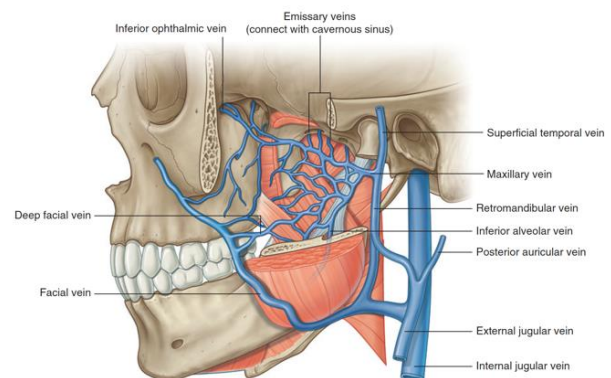
- We notice the veins are much larger than arteries.
- In both arteries and veins we have the same three basic layers:
 - ✓ **Tunica intima (innermost):** simple squamous epithelium and it's the same in both (A,V).
 - ✓ **Tunica media:** smooth muscle and its thicker in the arteries when compared it with veins also it's the thickest layer between all layers of artery.
 - ✓ **Tunica adventitia (outermost):** connective tissue and its thickest layer in all layers of the vein because the vein needs to dilate.



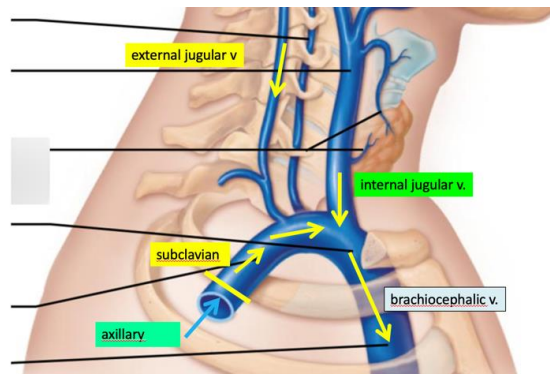
Veins of Head & neck:



(b) Veins of the head and neck, right superficial aspect



- **Superficial temporal vein:** its above the temporal bone (squamous part), has many branches that cover the scalp and goes down accompany with superficial temporal artery to meet the maxillary vein in retromandibular vein.
- **Maxillary veins:** its going to form a vein that behind or deep to the ramus of mandible called retromandibular vein.
- **retromandibular vein:** is equals superficial temporal vein + maxillary vein and it will branch into:
 - ✓ **Anterior branch:** will meet the facial vein and two veins will end up in the internal jugular vein.
 - ✓ **Posterior branch:** will meet the occipital vein posterior to forming external jugular vein.

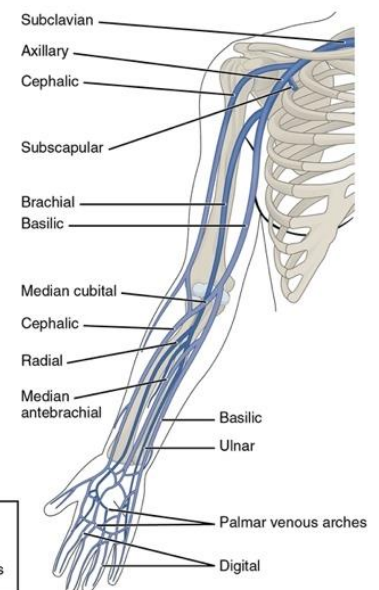


- **Internal jugular vein:** it's the main vein inside the skull and its deep to sternocleidomastoid muscle.
- **External jugular vein:** formed by meeting of occipital vein and posterior branch of retromandibular vein and drains into subclavian vein.
- **Axillary vein:** receive the blood from the upper limb, once it crosses the first rib it becomes subclavian vein.
- **Subclavian vein:** behind the clavicle and goes medial, it will join with internal jugular vein and both will form the brachiocephalic vein.
- **brachiocephalic vein:** the right and the left will join together and forming superior vena cava.

Note: this story is happened in both side (right, left), but there is a difference which is the brachiocephalic vein in the left is longer than the right one

Veins of the upper limb:

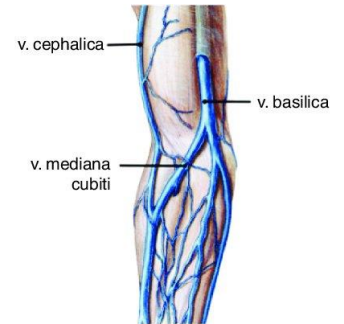
- **deep system:** runs deeply accompany with artery and have the same name of artery name:
 - I. **Radial and ulnar veins** run with radial and ulnar artery and they join together to forming brachial vein.
 - II. **Brachial vein** runs with brachial artery and will join with basilic vein (superficial branch) to form axillary vein.
 - III. **Axillary vein** run with axillary artery and receive the blood from cephalic vein (superficial branch) and continue to be subclavian vein after cross the first rib.
 - IV. **subclavian vein** runs with subclavian artery and as we said before it will join with internal jugular vein to forming brachiocephalic vein.



- **superficial system:** its under the skin and doesn't run with artery:
 - Cephalic vein:** on the lateral side and drains into axillary vein.
 - Basilic vein:** on the medial side and continuous upward to join with brachial vein to form axillary vein.

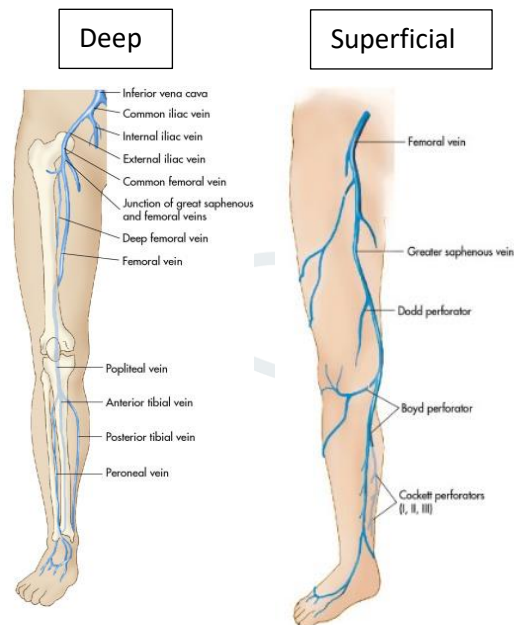
Note: we have something called cubital fossa (depression) that found in the elbow region and in the front of this fossa we will have median cubital vein which connect the two superficial veins (cephalic and basilic).

هذا هو الوريد اللي بنسحب منه الدم لما نعمل تحليل دم (:)



Veins of the Lowe limb:

- **deep system:** runs deeply accompany with artery and have the same name of artery name:
 - venous arch.**
 - Anterior tibial and posterior tibial veins** will join together in the popliteal region to forming popliteal vein.
 - Popliteal vein.**
 - Femoral vein:** receive the blood from Small (lesser) saphenous vein and it will become external iliac vein once it cross the inguinal ligament.



- **superficial system:**

I. Long (greater) saphenous vein:

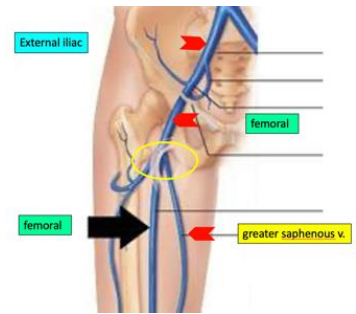
The beginning of greater saphenous vein of the lower limb is with venous arches in the foot (accompanying the arterial arches), and they collect in a vein that, in the medial side, goes anterior to the medial malleolus crossing ankle joint and goes superficially under the skin towards the inguinal region.

In its way, this vein is making connections with deep veins through **communicator veins**.

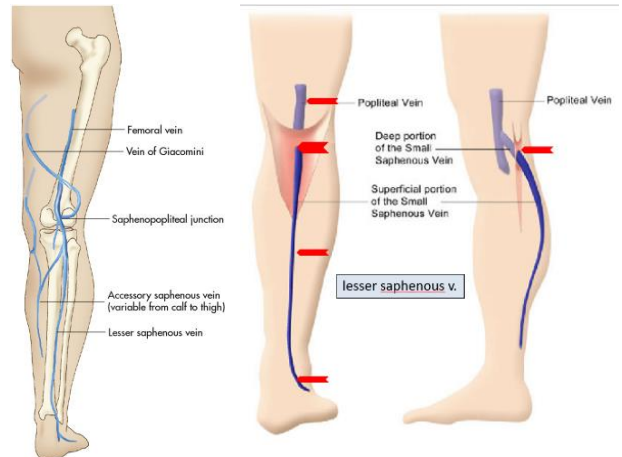
so, when muscles contract, they will make a pressure on the deep veins that take the blood from the superficial system into the deep system, pushing it up.

If valves in communicating veins are defected, blood will come from deep veins and accumulate into the superficial veins; in a situation called **Varicose veins** (دوالي).

Then as it goes on the medial side on the leg, medial to the knee and thigh (slightly anterior) and ends up in the femoral vein, linked by an important valve.

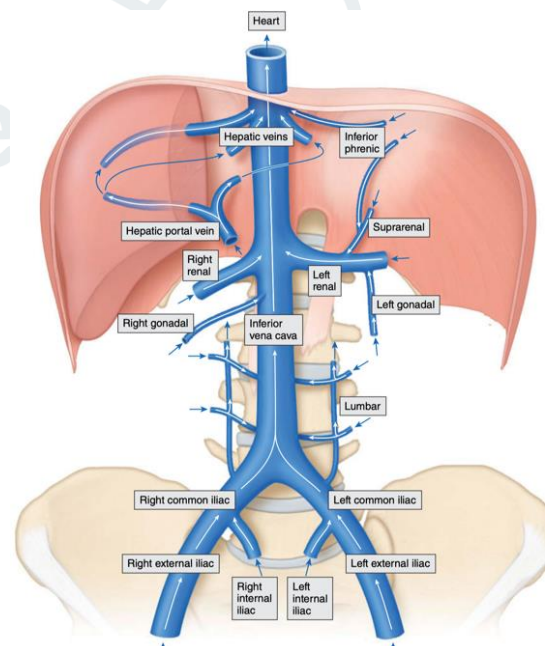


- II. **Short (lesser) saphenous vein:** starts on the lateral side posterior to the lateral malleolus, and goes up in posterior of the leg, then ends up in the popliteal vein, linked by an important valve.



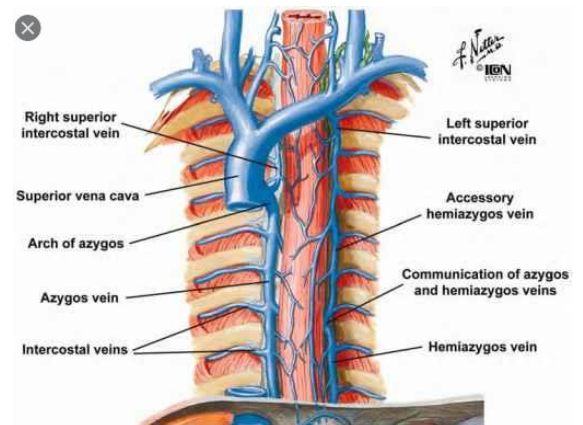
Vein of abdomen: below the diaphragm

- **Inferior vena cava:** receive the blood from all parts under the diaphragm.
- **Internal iliac vein:** draining the pelvis.
- **External iliac vein:** draining the lower limb.
- **Common iliac vein:** formed by joining of two iliac veins above.
- **Lumber veins:** draining the lateral and posterior abdominal walls, and they will join together to forming ascending lumbar (ilio-lumbar) veins which enter the thorax.
- **Renal veins:** they will join to the inferior vena cava, the left one is higher than right one.
- **Right gonadal vein:** drain into vena cava.
- **Left gonadal vein:** drain into left renal vein.
- **Hepatic veins:** just below the diaphragm.



Veins of thoracic: above the diaphragm

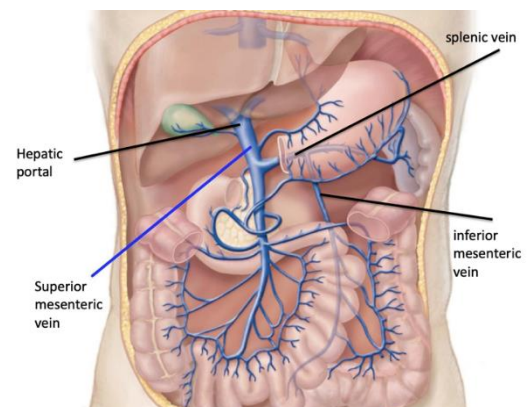
- **Azygous vein (right side):** arising from right ascending lumbar vein (right ilio-lumbar vein) and it will collect the blood from intercostal spaces, esophagus, hemiazygos, accessory hemiazygos, tracheal and drain into superior vena cava.
- **Hemiazygos vein (left side):** like azygous but its shorter in the region of thorax and end at the point where it communicates with azygous.
- **Accessory hemiazygos vein (left side):** begins at the fourth or fifth intercostal space and descends until reaching the end point of hemiazygos vein and it is communicating with azygous.



Note: these veins come with inferior vena cava, but it will drain into superior vena cava.

Portal circulation

- **Inferior mesenteric vein:** will drain into splenic vein.
- **Superior mesenteric vein:** will join with splenic vein to forming hepatic portal.



End of the lecture (Finally) :)