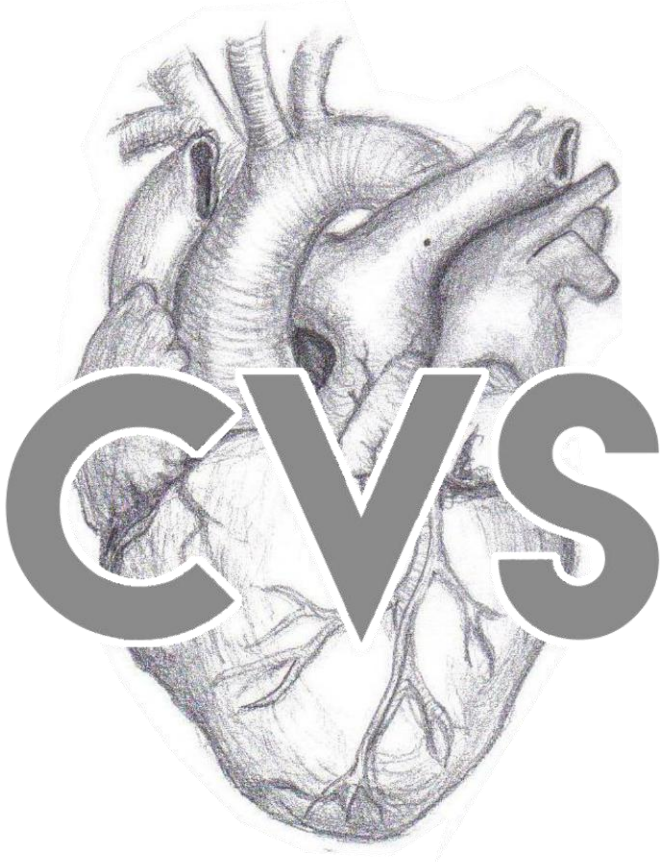


CVS

ANATOMY / HISTOLOGY

✓Sheet ○Slide ○Handout

Number

Histology Lab 1 {Lab3}

Subject

Blood vessels & Heart

Done By

Yahya Ameen

Corrected by

.....

Doctor

Dr.Faraj Bustami

Date: **00/00/2016**

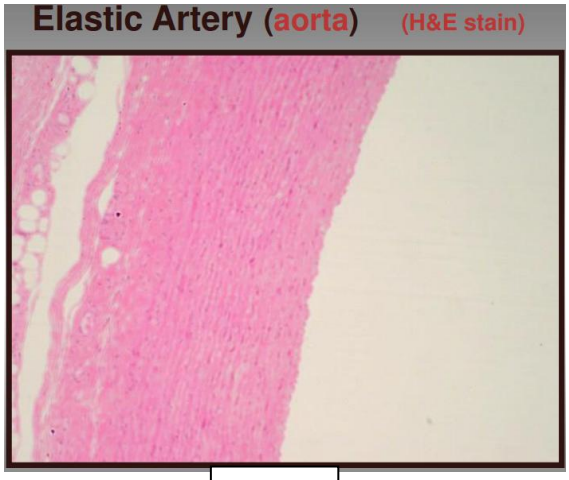
Price:

Histology Lab 1 {3rd lab}

~ The slides are included in this sheet.

❖ Slide2:

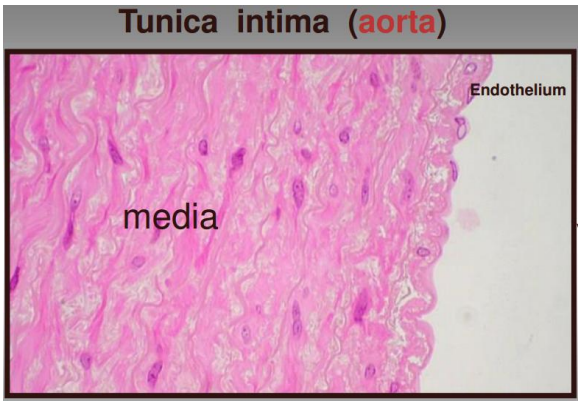
- H&E stain: is a classical stain, non-differential stain, using of a classical stain we can't differentiate between components.
- In the slide "in the media" we can't differentiate between components .. the smooth muscle, elastic tissue & collagen, they all stained the same in H&E "eosin", they all appear similar "**red**".
- We should use a differential stain !



Slide2

❖ Slide3:

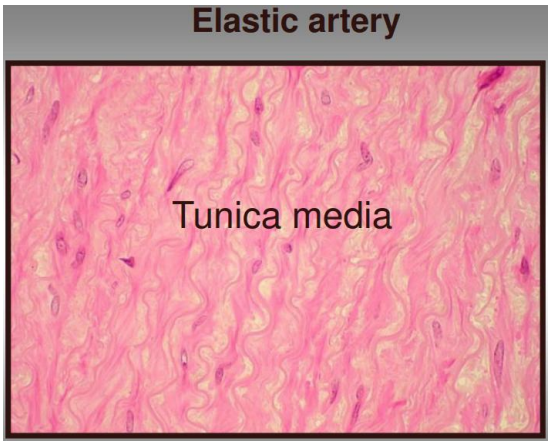
- Higher magnification to the elastic artery {e.g. Aorta}.
- Tunica Intima: we hardly can see the nuclei of endothelium.
- Basal lamina is **not seen**, under the basal lamina is subendothelial connective tissue.
- The outer borders "internal elastic lamina" **Not seen**.
- Internal elastic lamina apparent in muscular part Not elastic part.



- Tunica Media " notice the nuclei": contains .. collagen, smooth muscle & elastic tissue.
- The spiral lines are elastic laminae.

Q: How to differentiate between smooth muscle & collagen here?
~ Hard, because they give the same color.

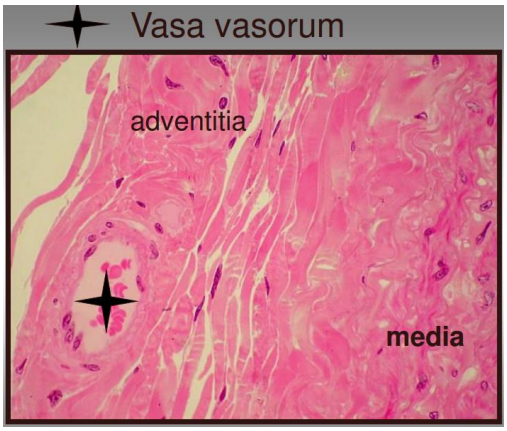
Q: Which structure produces the collagen & elastic fibers here?
~ **The Smooth muscle** produce collagen & elastic, Not fibroblast.
#Remember that fibroblast produce collagen too, but here there is no fibroblast.



❖ Slide4:

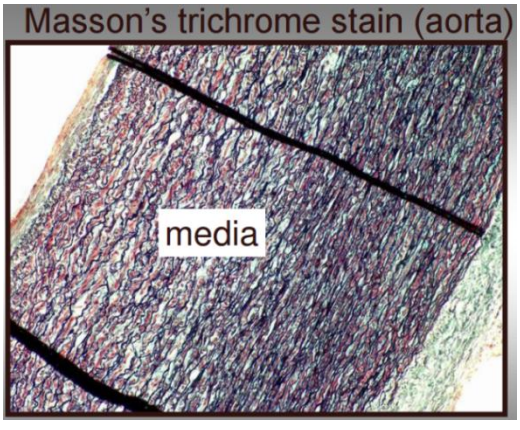
- Tunica media: notice the nuclei of smooth muscle surrounded by collagen & elastic tissue all stained the same.

❖ Slide5:

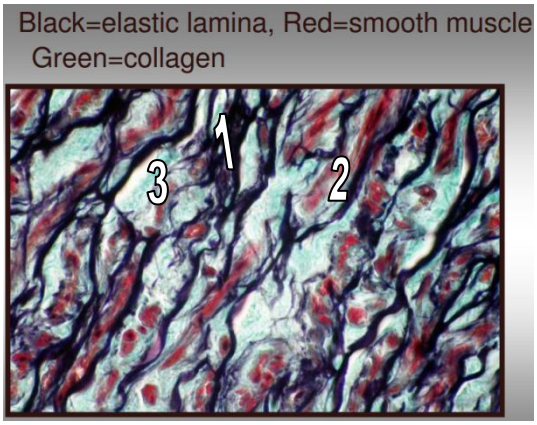


- Notice the outer media & adventetia.
- In the adventetia is the vasa vasorum "vessel of the vessel": its function to provide blood supply, oxygen & nutrients to the outer layers.. *{notice the +}*
- In Large vein the wall is much thinner than the elastic artery. However, the blood which is inside it is deoxygenated "poorly oxygenated", so it has to have vasa vasorum to supply the wall with oxygenated blood.
- **Vasa Vasorum most abundant in large veins .. important !**
- Most nemrous in large veins, then elastic arteries, then muscular arteries.
- The inner layers "intima & most of media": get what they need by diffusion.

❖ Slide6:



- This is a **Masson's trichrome stain** "differential stain": stain the elastic lamina with blue to black, stain the collagen with green & smooth muscle with red.



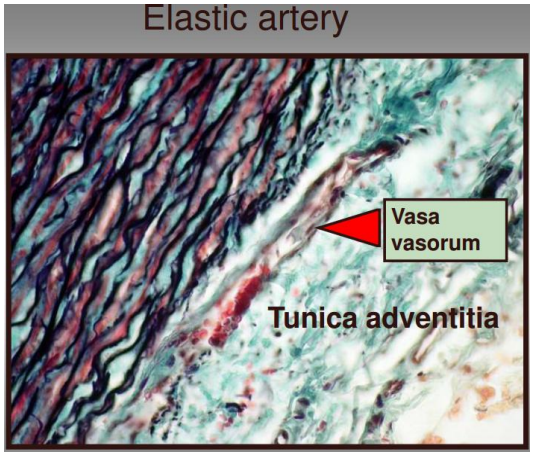
❖ Slide7:

- Black: elastic laminae.
- Red: is smooth muscle.
- Green: is the collagen.

Q: Which of these colors or numbers responsible for converting intermittent flow of blood coming out from the heart into continuous flow?
~ The **black elastic lamina**, because it can recoil, contract and pump the blood in diastole phase, when heart isn't pumping.

- In the wall of aorta there is elastic lamina it expands during systole "ejection phase" high amount of blood fill the aorta, while in diastole it recoils and pushes the blood to periphery.
  There is time that the heart pump blood and there is time that it doesn't, so the blood stream that come out from the heart is intermittent, in systole there is blood "pump", in diastole no blood pumped, the brain can't tolerate intermittent blood flow, thus this intermittent flow should be changed to continuous one .. this is achieved by elastic artery. Elastic artery bulged by blood in systole, **filled with blood**, the blood pumped to peripherals by ventricles pumping power "primary pump", and **recoil** "eject" the blood to the peripheries during diastole make it a "secondary pump".

#In diastole blood fill the heart & pumped from the heart in systole.
~ Outer media in elastic artery stained by Masson's trichrome stain "black".
~ Most of Tunica adventitia is green; because it is full of collagen.

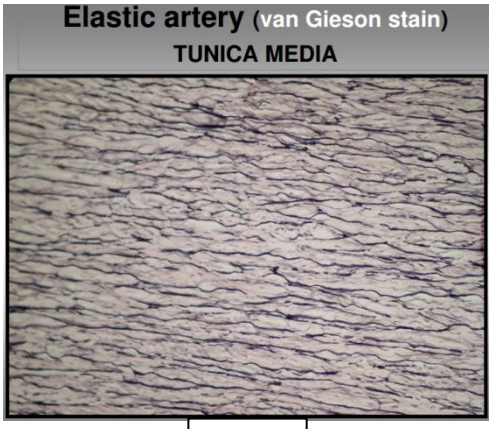


❖ Slide8:

- Notice the outer media & adventitia stained by Masson's trichrome stain.
- Notice vasa vasorum in elastic artery, but much more in large vein.

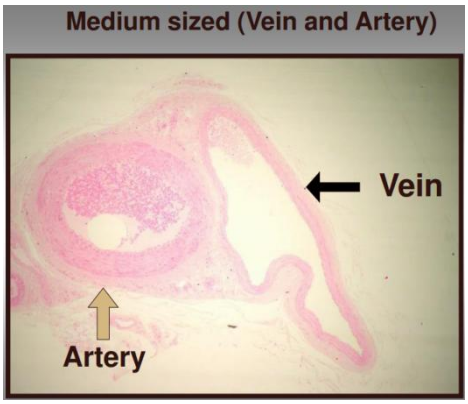
❖ Slide 9&10:

- Van Gieson stain: it's a differential stain "like Masson's trichrome stain".. Just know this!.
- It spouses to stain the elastic between blue & black, stain smooth muscle yellow to brown & collagen red .. but it is not accurate, so forget about these two slides.



Slide9

❖ Slide11:

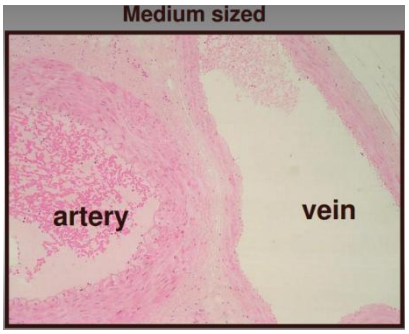


- **Medium size artery & medium size vein comparison**: Most of the arteries & veins in our body are medium size arteries & veins.
  Overall, the **medium size artery** has a very thick wall & narrow lumen .. But, in **medium size vein** very thin wall & wide lumen.
- **Layers:**
  - ✓ The intima is hardly recognized.
  - ✓ Tunica media is the main layer in the artery & the adventitia has the same size or a little bit smaller ..
  - ✓ In contrast, the vein has small media & thick adventitia "the thickest".

#Remember: Vein that is near to the artery is deep vein, inside the deep fascia.
#Superficial vein outside the deep fascia beneath the skin.
#After death blood accumulates in veins.
#We may see blood cells in the artery, because these slide taken from animal, the technician might put a clamp on the artery, so blood accumulate in the artery, but normally the blood accumulate in veins after death.

❖ Slide12:

- In the vein small "thin" media, few muscles. While, adventitia is the main layer.

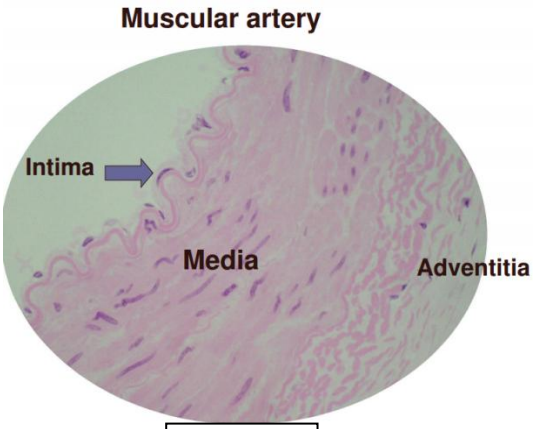


❖ Slide13:

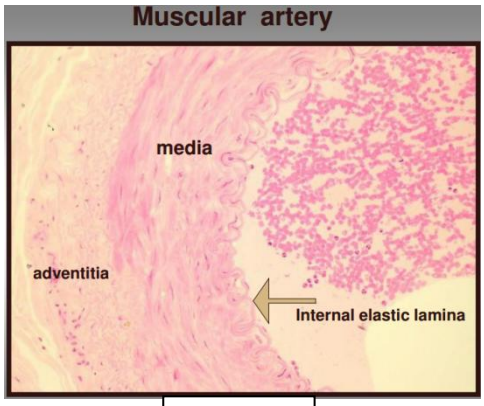
- Same as the previous slides, in the artery the lumen is regular, we see internal elastic lamina.

❖ Slide14,15&16:

- Muscular artery "H&E stain".
- The intima: we hardly see the nuclei of endothelium "simple squamous epithelium".
- Below endothelium is the basal lamina **Not seen** in this ***{slide14}***, below basal lamina a minimal subendothlial connective tissue Not seen.
- The borders "tortuous line": the internal elastic lamina:
  - ✓ When it is continuous, it indicates "mostly" a muscular artery, we make sure when we see the external elastic lamina.
- Outer to the intima is the media: filled with smooth muscle, with few elastic and collagen.



{Slide14}



{Slide15}

Q: How can I count the number of layers in the media? By **number of nuclei**, every nucleus is a layer. More than 4 layer in this slide.
* More than 4 layers it is medium size artery.
* If it has 4 or less .. then it is an arteriole.
1 layer .. small arteriole.
2-4 layers .. this is a large arteriole.

- Outer borders of the media has several layers of external elastic lamina.

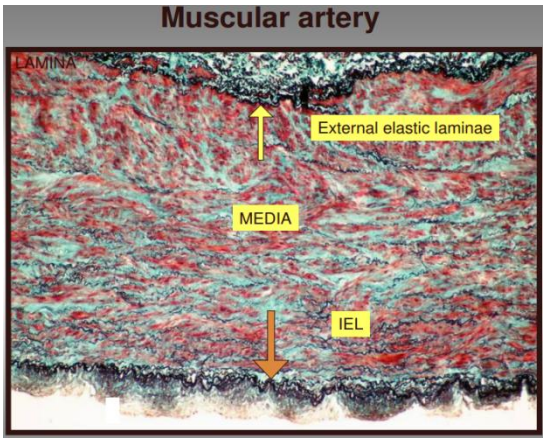
- Then the adventitia: there are nerves that supply the smooth muscles, make them contract "sympathetic".

Q: Why the muscular artery named **distributing artery**?
Because they control the amount of blood distributed by contraction & relaxation.
~ When these smooth muscles contract they narrow the lumen, so limit the blood flow, and when they relax will extend the lumen and increase the blood flow.
Contract > narrow the lumen > limit blood flow to the organ.
Relax > extend the lumen > increase blood flow to the organ.

~ Examples on this is the brachial, femoral, ulnar arteries.

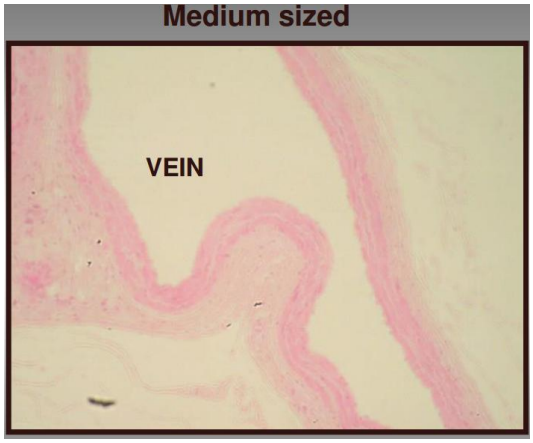
#Tunica Media is full of smooth muscles, if you count them you will find 10-12 layers.
#Sometimes we see "internal elastic lamina" in the vein & elastic artery, but they are usually incomplete, it is complete only in the muscular artery.
#External elastic lamina is not apparent here.

❖ Slide17:



- Stained by differential stain "Masson's trichrome stain".
- Notice the Internal elastic lamina "IEL" stained black 2-3 layers, and the external lamina is apparent here.
  When ever you see these tow laminae . this indicates a muscular artery .. never forget it!
- In the media mostly red "smooth muscles", there is also green "collagen" & few elastic "tortuous lines".

❖ Slide18:



- Tunica Media is thinner than adventitia "the thickest".

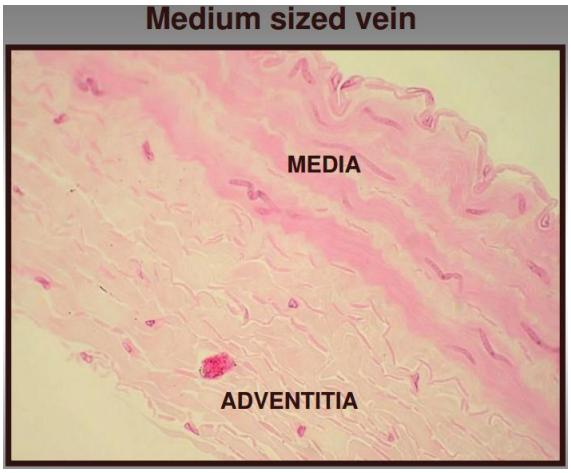
~ Two features of the medium size vein:

1) Poor in smooth muscles in the media, Low-resistance (collecting system): to carry blood from the body back to the right side of the heart.
2) Rich in collagen in the adventitia, Low-pressure (storage system): holding over 60% of all blood at anytime at a pressure blew about 18 mm Hg.

Note: Collagen gives this blood vessels a compliance feature ..
Compliance "المطاوعة": a compliant structure has a large change in volume achieved with a relatively small change in transmural pressure "low pressure", it is the inverse of elastic recoil.

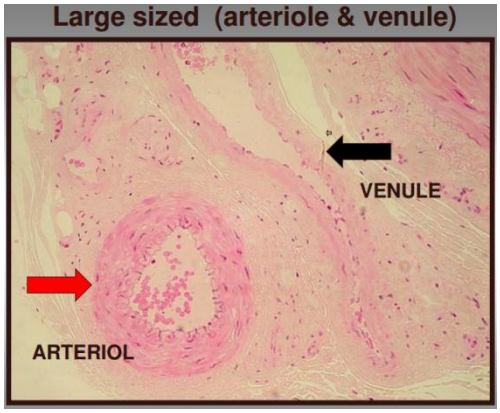
#Keep in mind: Veins are highly stretchable with little elastic recoil .. little resistance to flow & store high amount of blood under low pressure.
#Keep in mind: Veins are more compliant than arteries.

❖ Slide19:



- We may see internal elastic lamina but it is never complete "incomplete" in the vein.
- Tunica Media thin, 2-3 muscles only, low resistance.
- Adventitia is the major layer.
- The vein innervated by sympathetic to supply smooth muscle, every blood vessel that has smooth muscle innervated by sympathetic.
- Every blood vessel has smooth muscles can resist blood flow, so called Total peripheral resistance !
- The vein has little resistance to blood flow.

❖ Slide20:



- This is a large arteriole, because it has almost 4 layers "count the nuclei".
- Presence of fenestrated internal elastic lamina "tortuous line".
- It has a relatively thick wall & narrow lumen.

#Artery >Arteriole > Capillary > Venule > Vein.

- Post-capillary venule: formed by union of several capillaries.
- Diameter range (10-50µm).
- Small venule (10µm), lacking tunica media & its structure and function is similar to capillaries structure.
- The capillaries structure: endothelium resting on thin basal lamina, thin adventitia with few collagen, absence of media, similar to venules.
- The function capillaries: important sites for exchange of fluid between blood and tissues .. small venule do the same function.

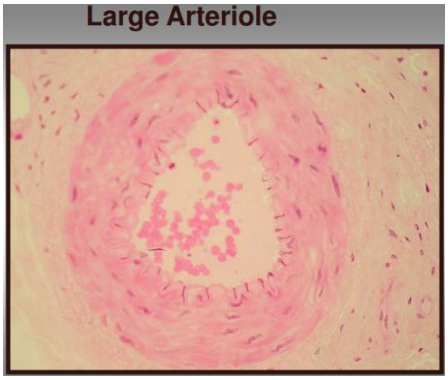
- The venules have a process called diapedesis: it is the leakage of blood cells "leukocytes" from the blood to the tissue which pass between endothelial cells to escape into the surrounding tissues e.g. neutrophil.
- Presence of layers of muscles this is a large venule, if it is absent then it's a small venule.
- In small veins: circular smooth muscles form a complete tunica media.
- When venule becoming larger, muscle layers become complete.

Q: What controls the activity of these smooth muscles?
~ There are mayogenic activity and sympathetic activity affect smooth muscles..
Myogenic activity works without external stimulation, these muscles will contract.. **How?**
Depolarization will happen, sodium (Na^+) channels open, depolarization down to threshold, action potential, then contraction.
Myogenic activity is the base of vascular tone "a state of partial constriction" which establishes a baseline of arteriolar resistance.
Sympathetic nervous system increases the myogenic activity, narrows the arterioles, therefore increases the contractility.. Extrinsic factor.

Every organ receives blood according to its metabolic activity, if the metabolism is high, a lot of metabolites (local or intrinsic factors) controls blood flow "more lactic acid, adenosine, CO2, K^+", local metabolites will override the sympathetic constriction effect & vasodilate the arteriole.

- Myogenic activity contracts without extrinsic stimulus, spontanuos depolarization
How depolarization occur ? sodium channels open spontaneously by itself.
- If there is vascular tone > partial contraction occur > increased by sympathetic.
- Sympathetic increase constriction "increase the vascular tone".

Slide21:



- Large arteriole "4 layers".
- Metarteriolar & precapillary muscles are poorly innervated.
- Local metabolites control the precapillary sphincters, and hence the blood flow.
- The strongest vasoconstrictor is Angiotensin II, also cold consider a vasoconstrictor.
- Vasodilator metabolites: NO, CO_2 in brain arteries, heat & histamine.

~ When blood volume that reaches the kidneys decreases, this will lead to secretion of rennin in response to renal sympathetic activity..
- Rennin converts angiotensinogen to angiotensin I&II (II is the strongest vasoconstrictor) through angiotensin converting enzyme "ACE" in the lung.
#Angiotensin stimulate releasing of aldosterone from adrenal.

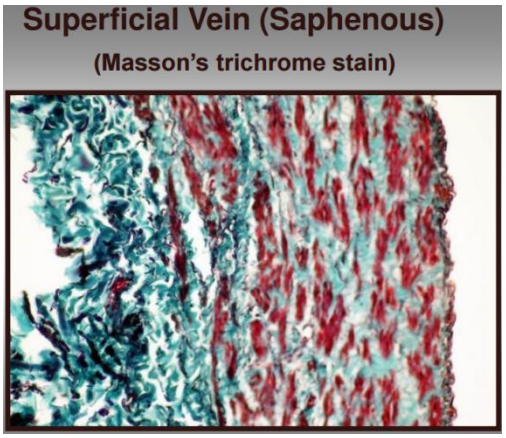
Remember: Mean arterial blood pressure = Cardiac Output (C.O)* Total Peripheral Resistance "TPR"

~ Arterial blood pressure is a vital sign "to know if the patient in danger".
- If it was lower than normal (lower cardiac output or lower Total peripheral resistance) this be due to:

Cardiac output: the amount of blood pumped by ventricles per a minute, maintain the blood pressure.

- ✓ High histamine; due to certain drug or allergic reaction.
- ✓ Infarction, decreasing in pumping power "weakness".
- ✓ External or internal bleeding.
- ✓ Scorpion or snake bite; release of histamine cause vasodilatation.. give a drug that increases the resistance.

❖ Slide22:



- ➢ Saphenous vein: is a superficial vein, outside the deep fascia, under the skin, Not supported by muscles.

#Deep vein: run with the artery inside the deep fascia, supported by muscles, it partially contract, thus it pumps the blood back to the heart.
#2 deep veins accompany the artery "vena comitans"(الأوردة المرافقة) , inside the muscles, the muscles compress them, help in the return of blood to the heart this is called muscular pump.

* Gastroenimius & psoas muscles:
~ Psoas muscle called heart in the leg, inside the psoas there are veins, when it contracts compresses the veins and blood will return to the heart.

#Keep in mind: Superficial veins opposite to the deep, they are not supported by muscles that makes them contract.
- Presence of longitudinal smooth muscles in media and adventitia support the strength of the wall of superficial vein.
#Remember: When the muscle runs longitudinally it doesn't narrow the lumen, when it runs circularly it narrows the lumen.

Q: Is there a connection between superficial & deep veins?
~ Yes .**perforators**, because they perforate "pierce" the deep fascia which separates the superficial from deep vein, valves are present, blood flow from superficial to deep, back to the heart.
* If the valve ruined the blood will flow from deep to superficial, superficial vein will be exposed to high pressure "not normal", the vein will vasodilate & twist .. **varicose veins will occur.**

~ Deep Vein Thrombosis "DVT":

- Most common in popletial vein.
- Consequence of: postoperative, post labor, immobilized patient "e.g. paralyzed, quadriplegic", hypercoaguability "e.g.cancer patient".

A patient came to you suffering from DVT, the thrombus will cause emboli
emboli get out, where it will go?
- To the lungs !

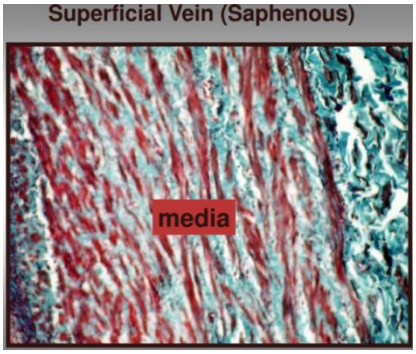
Route of embolus to the lung:
- Popliteal vein > femoral vein > external iliac vein "join the internal" > form common iliac > the two common iliac form the inferior vena cava "I.V.C" > I.V.C go to the right atrium > the blood will go out from right atrium to right ventricle > right ventricle pump the blood with the embolus to the lungs by pulmonary trunk .. so the pulmonary trunk and its branches will be filled of emboli, it blocks the pulmonary trunk itself (by blocking one of its branches) shots of emboli blocks the branches, therefore blocking the main trunk.

Pulmonary trunk is blocked "embolism", then what will happen?
- Reduction in the cardiac output of right ventricle ..
If you measure blood pressure inside pulmonary trunk, you will find low blood pressure, this will decrease blood that goes to the lungs.
The lungs return the blood to the left atrium, so decrease in the blood that returns to the left ventricle, therefore reduction in the cardiac output of the left ventricle "heart failure".

#The beginning of the problem was on the right and the consequence affects the left, decrease in the output of right ventricle & then decrease in the output of the left ventricle.

#Remember: The left part of the heart receives blood from the right part, any defect in the right will affect the left too.
#After a procedure the patient should move his legs to avoid DVT, you should tell him.

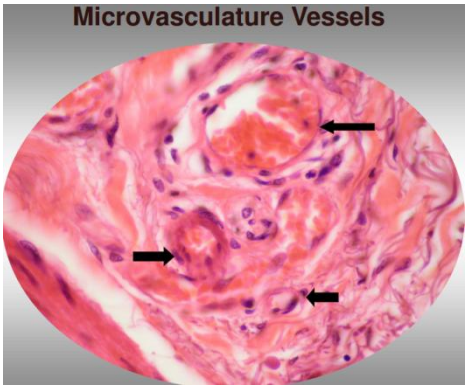
❖ **Slide23**:
- Saphenous vein is superficial NOT deep.
- The media & adventitia full of longitudinal smooth muscles *{notice red color}* ..to support the wall.
- Tunica adventitia has smooth muscles only in veins.



❖ Slide24:

- Tunica Adventitia has longitudinal muscles they support & don't narrow the lumen .. *{notice red color on Adventitia}.*

❖ Slide25:



- Microcirculation: this is section illustrates arteriole *{upper arrow}*, we hardly see single nucleus "small arteriole".. Venule *{middle arrow},* capillary *{lower arrow}*.

~ Arteriole is the major resistance vessel, contributes to the total peripheral resistance, richly supplied with sympathetic.
- Arteriole divides to metarteiole, then to precapillary sphincter, which is between metarteriole and the true capillary.
- Precapillary sphincter: their muscles action depend on organ metabolites.

~ **Types of Capillaries** : Continuous, Fenestrated, Discontinuous.

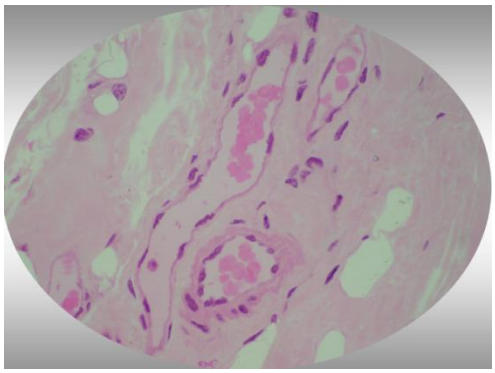
1) Continuous capillary: exist in blood brain barrier "BBB".
   - ✓ The blood brain barrier is a modified capillary that has a reduction in its permeability, tight junction in the endothelium "no gaps between them", thick basal lamina, above basal lamina there is astrocyte, all these features increase the thickness and decrease permeability to restrict and determine what enters the brain.

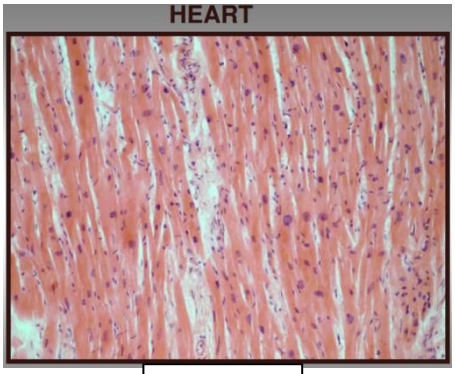
#Remember: Blood will go to the thymus with all of its content.
#Keep in mind: BBB is modified capillary Not collagen nor anything else !

2) Fenestrated capillaries: no gaps but there are tiny holes in the cells (e.g. glomerulus), in the kidney "glomerular capillaries" function as a filter of blood.
3) Discontinuous capillary: sinusoids in red pulp of spleen, bone marrow & liver.

❖ Slide26:

- Cross section that shows venules.





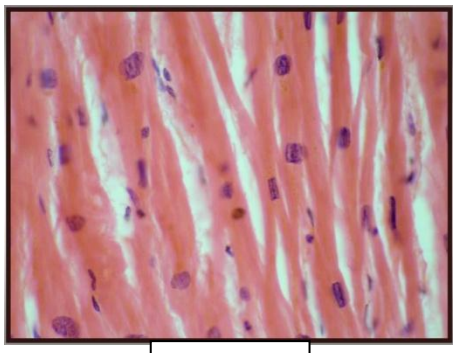
{Slide27}

❖ Slide27,28&29:

- Cardiac muscle.

~ Skeletal muscle VS Cardiac muscle:

- Skeletal muscle fiber = skeletal muscle cell.
  Cardiac muscle fiber = group of cardiac muscle cells "chains of cells".
- The group of cardiac muscle cells are separated by septa called intercalated disks; the most important structure in the intercalated disc is the **gap junctions**.
- Gap junction: Area of low electrical resistance allowing rapid spread of action potential from cell to cell.
- **Gap junctions present in cardiac muscle cells only**.
- Notice the branching, , uni-nucleus, centrally placed.. ***{slide29}***



{Slide29}

- The most important difference is the presence of gap junction in cardiac muscle cells.
-No intercalated disk, No gap junctions in the skeletal muscle; if there are gap junctions, then there will be no partial contraction.
#Keep in mind:Spread of action potential is the gap junction function only, **NOT** the branching .

- In skeletal muscle, you can stimulate only part of the skeletal muscle to contract (e.g. biceps), by motor units.
- Every skeletal muscle composed of group of fibers that innervated by branches from the nerve. For example, the biceps has 1000 motor units, you can stimulate only 100 of them, lead to partial contraction "muscle tone" .. DOES NOT HAPPEN IN THE HEART !

***Muscle tone**: is a partial contraction that occur in skeletal muscle not in cardiac.

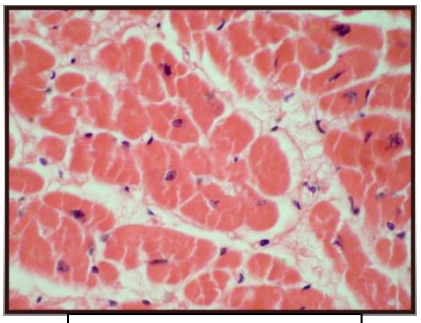
- The skeletal muscle cell is multi-nucleated, peripherally placed.
  In cardiac muscle cell single nucleus, centrally placed.
- Actin and myosin filaments form fibrils, and fibrils form fibers.. present in BOTH skeletal & cardiac.
- Actin & myosin arranged in sarcomeres .. present in BOTH.
- T-tubules located in the cardiac muscle in the Z-line & greater in diameter.
- In skeletal muscle the T-tubules located at the A-I junction.
- Sarcoplasmic reticulum present in both.
- Mitochondria more numerous and larger in cardiac muscle.
- Skeletal muscle has 2 sacs at the two sides of T-tubules called terminal cisternae "calcium stores" in the triad.
- In cardiac muscle, no sacs, only small expansions which are closely associated with the T-tubules, adjacent to sarcolemma, the association here called a diad.

- In cardiac muscle to increase the concentration of Ca^{+2} in cytoplasm has two sources:
  I. The extracellular Ca^{+2} pool: influx of Ca^{+2} through channels.
  II. Ca^{+2} pool in the lumen of sarcoplasmic reticulum.

- In skeletal muscle release of Ca^{+2} from its stores only.
- Skeletal muscles susceptible to tetani "continuous contraction", while cardiac muscle **NOT** susceptible.

Notes:
- Ca^{+2} entry from extracellular pool triggers relax of Ca^{+2} from the intracellular pool "SR" .. Ca^{+2}-induced Ca^{+2} release.
- Ca^{+2} important in continuous contraction.
- They used to give an IV calcium (10ml) for the patient for any disease "given slowly", not used anymore because of the risk of this injection.
- If calcium given rapidly lead to tetanization in the heart & kill the patient.
- Ca^{+2} increase during systole and decrease during diastole .. what enters in systole should get out in diastole or tetanization will occur.

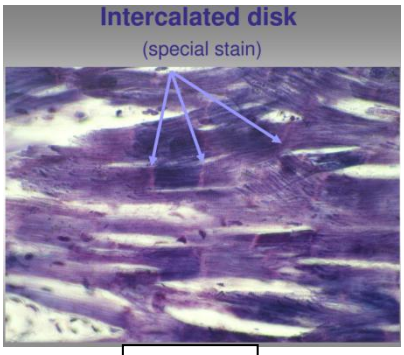
❖ **Slide30**:
- Cross section in cardiac muscle.
- Notice the nucleus in the center.
- Not appeared in all cells, because it depends on the level of the section, if it was on the center we can see the nucleus, if it was on the periphery we can't see the nucleus.



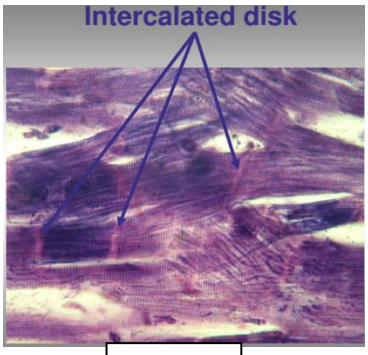
{Slide30}: Cross section.

❖ **Slide31,32&33** *{see next page}:*
- Notice branching of cardiac muscle.
- The crosswise lines are the intercalated discs.
- Intercalated disc *{the arrows}*: composed of fascia adherence, zona adherence & gap junction.
- Fascia adherence & Zona adherence contribute in adhesion.
- Gap junction allow spread of action potential "cardiac impulse" from cell to cell.
- Notice the cross striation (sarcomeres) which present in cardiac & skeletal muscle.. *{slide32}*

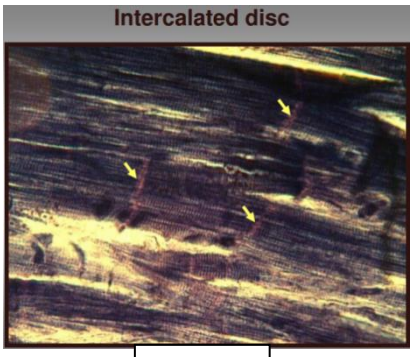
Note: For the contraction to occur the cell membrane should enter inside and make a tunnel in the muscle cell, to let the action potential reach deep to the fiber to increase concentration of the heads "contraction".



{Slide31}

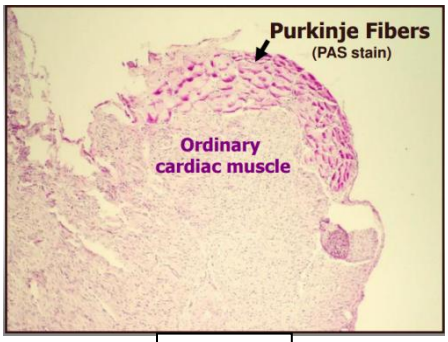


{Slide32}



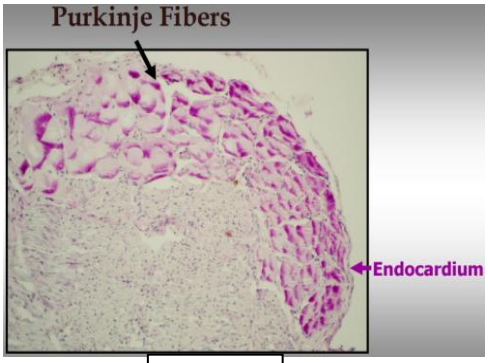
{Slide33}

❖ **Slide34,35,36&37**:

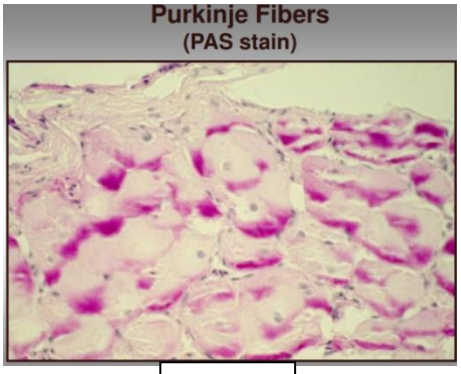


{Slide34}

- Purkinje fibers: **Modified cardiac muscle fibers**, specialized for conduction of electrical impulse, transport action potential and spread it to all ventricle muscles.
- Location: Subendocardial "near the blood".
- Function: Conduction of cardiac impulse, they are NOT specialized in contractility.
- Thicker & larger than ordinary cardiac fibers.
- Rich in glycogen stained by "PAS stain", accumulate on myofibril remnants.
- Pale centers "white": the cell look empty due to absence of myofibrils..*{slide36}*
- Contain junctions "gap junctions".
- T-Tubule NOT present.



{Slide35}



{Slide36}

- The heart is functional syncytium: Atria muscles "Syncytium" separated from ventricular muscles by skeleton of the heart "حلقة ليفية", the only connection between them is the AV bundle "small muscle".
- AV bundle runs posterior to the membranous part of intervetricular septum.
- Atrio-Ventricular part (between left ventricle & right atrium) susceptible to congenital defect VSD.

* Anatomical syncytium: no septa between cells.

- Conducting system: begins the action potential and spread it ..
  First part of conducting system is the SA node "pace maker", present in the wall of right atrium, near to the S.V.C opening, starts the action potential.
  Then action potential spread to the AV node, then to AV bundle which gives two branches right & left, finally it will reach the Purkinje fibers which will spread it to the wall of ventricles.

Notes:

- During VSD procedure the doctor might hit the AV bundle accidently, AV bundle disrupted, this used to be fatal, but nowadays they save the patient with artificial pacemaker.
- AV bundle is very vital part of the heart, defect in the bundle, atria will follow the pacemaker and the ventricles will try to create their own pacemaker.
- Cardiac muscle divided to contractile or conduct, most of ordinary muscles are contractile, contract and pump blood.
- Purkinje fibers are NOT autonomic (symp. & parasymp).
- In skeletal muscle there is modified skeletal muscle fiber called muscle spindle.

****

- I apologize if I made any mistake, if you find any share it please.
- Good Luck <3