Pathology of vascular system

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Lecture 2

- **ARTERIOLOSCLEROSIS (Hypertensive vascular disease) :**

- There are two forms of arteriolosclerosis;
  - **hyaline & hyperplastic ,**both of them are related to hypertension

Hypertension

- Systemic and local tissue blood pressures must be maintained within a narrow range to prevent untoward consequences.
- **Low pressures** (hypotension) result in inadequate organ perfusion and can lead to dysfunction or tissue death.
- Conversely, **high pressure** (hypertension) can cause end organ damage and is one of the major risk factors for atherosclerosis

- According to the newest guidelines, individuals with diastolic pressures above 80 mm Hg or systolic pressures above 120 mm Hg are **considered to have clinically significant hypertension.**
- Approximately 46% of individuals in the general population are therefore hypertensive based on these newer criteria. However, such cutoffs do not reliably assess risk in all patients; for example, when other risk factors such as diabetes are present, lower thresholds are applicable.

Blood Pressure Categories

American Heart Association | American Stroke Association

BLOOD PRESSURE CATEGORY	SYSTOLIC mm Hg (upper number)		DIASTOLIC mm Hg (lower number)
NORMAL	LESS THAN 120	and	LESS THAN 80
ELEVATED	120 – 129	and	LESS THAN 80
HIGH BLOOD PRESSURE (HYPERTENSION) STAGE 1	130 – 139	or	80 – 89
HIGH BLOOD PRESSURE (HYPERTENSION) STAGE 2	140 OR HIGHER	or	90 OR HIGHER
HYPERTENSIVE CRISIS (consult your doctor immediately)	HIGHER THAN 180	and/or	HIGHER THAN 120

• Hypertension has the following effects on blood vessels

1.It accelerates the process of atherosclerosis.

2.Causes structural changes in the blood vessel wall that predisposes to:

a. Aortic dissection.

b. Cerebrovascular hemorrhage.

3.Induce changes in arterioles referred to as **arteriolosclerosis.**

- **Regulation of normal blood pressure:**
- The blood pressure level is determined by the interaction of multiple genetic, environmental, & demographic factors that influence **two important hemodynamic variables: cardiac output & total peripheral resistance in addition to role of kidney:**

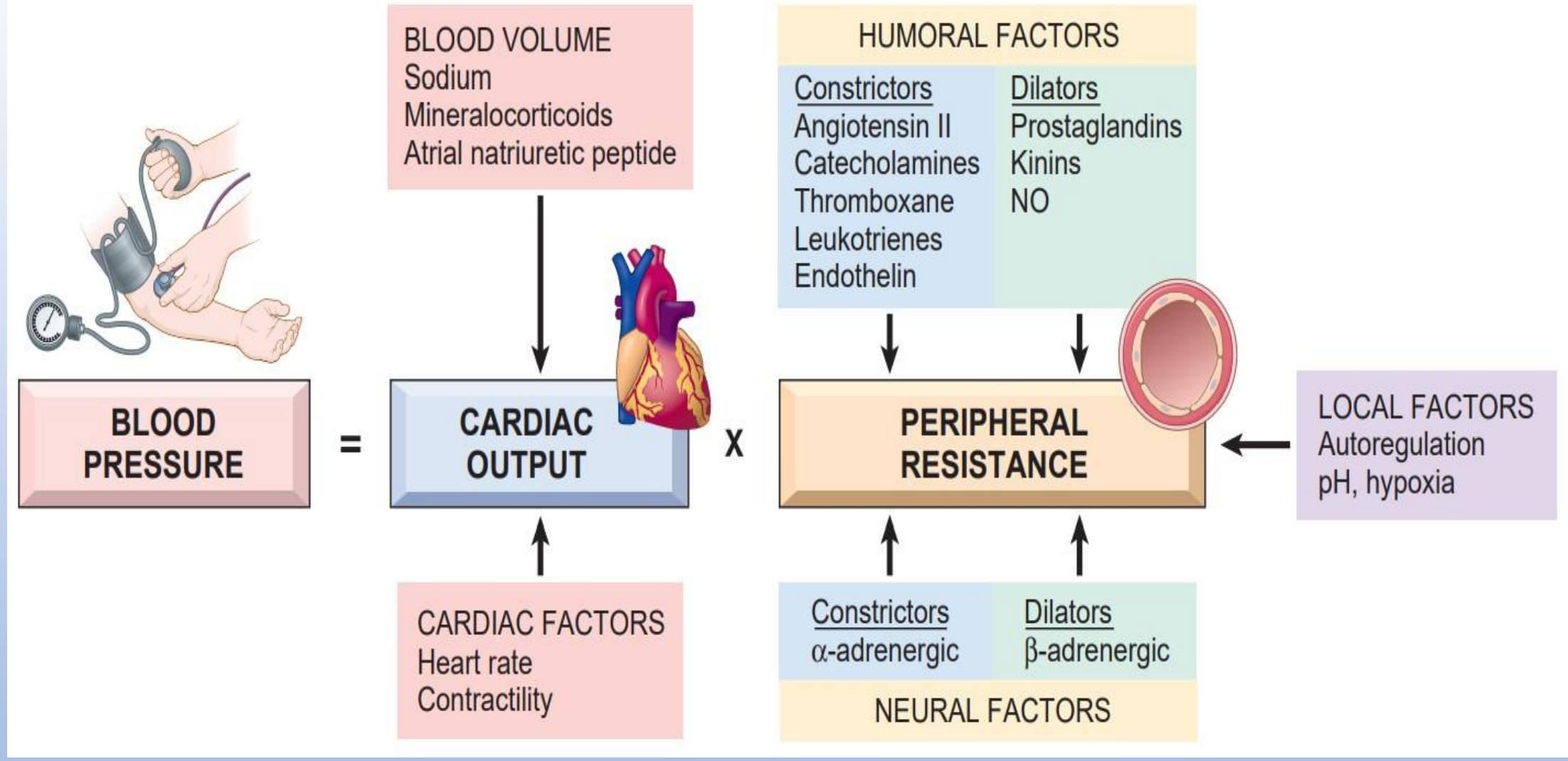
1. **Vascular resistance** is regulated at the level of the arterioles, influenced by neural and hormonal inputs, this hormonal influences control the vascular tone by a balance between vasoconstrictor factors (e.g. angiotensin II and catecholamines) & vasodilator factors (e.g. prostaglandins, & NO).
2. **Cardiac output** is determined by heart rate and stroke volume, which is strongly influenced by blood volume, blood volume in turn is regulated mainly by renal sodium excretion or resorption.

3. Renin a major regulator of blood pressure, is secreted by the kidneys in response to decreased blood pressure in afferent arterioles. It cleaves plasma angiotensinogen to angiotensin I, which is converted to angiotensin II by angiotensin-converting enzyme (ACE) .Angiotensin II raises blood pressure by

(1) inducing vascular contraction

(2) stimulating aldosterone secretion by the adrenal gland (increase sodium resorption (i.e water) -----increase BP

(3) increasing tubular sodium resorption.



Blood pressure regulation. Diverse influences on cardiac output (e.g., blood volume and myocardial contractility) and peripheral resistance (neural, humoral, and local effectors) impact the output blood pressure.

- **Causes of Hypertension:**
- **1- Essential :** The majority (90% to 95%) of hypertension is idiopathic or essential hypertension (within these cases about 95% of cases are benign hypertension, & 5% are malignant or accelerated hypertension).
- Essential hypertension result of interacting genetic and
- environmental factors.
- Even without knowing the specific lesions, it is reasonable to suppose that small changes in renal sodium homeostasis and/or vessel wall tone or structure act in combination to cause essential hypertension.

2- **Secondary:** 5% of cases are secondary hypertension (within these cases about 95% are malignant hypertension, & 5% are benign hypertension).

- Most common causes of secondary hypertension are: a-**Renovascular hypertension**, renal artery stenosis causes decreased glomerular flow and pressure in the afferent arteriole of the glomerulus, this induces renin secretion leading to increased blood volume and vascular tone via angiotensin and aldosterone pathways.
- **b-Primary hyperaldosteronism** is one of the most common causes of secondary hypertension, it may be idiopathic or less commonly caused by aldosterone secreting adrenal adenomas

Essential Hypertension
Accounts for 90%–95% of all cases
Secondary Hypertension
Renal
Acute glomerulonephritis
Chronic renal disease
Polycystic disease
Renal artery stenosis
Renal vasculitis
Renin-producing tumors
Endocrine
Adrenocortical hyperfunction (Cushing syndrome, primary aldosteronism, congenital adrenal hyperplasia, licorice ingestion)
Exogenous hormones (glucocorticoids, estrogen [including pregnancy-induced and oral contraceptives], sympathomimetics and tyramine-containing foods, monoamine oxidase inhibitors)
Pheochromocytoma
Acromegaly
Hyperthyroidism (thyrotoxicosis)
Pregnancy-induced (preeclampsia)
Cardiovascular
Coarctation of the aorta
Polyarteritis nodosa
Increased intravascular volume
Increased cardiac output
Rigidity of the aorta
Neurologic
Psychogenic
Increased intracranial pressure
Sleep apnea
Acute stress, including surgery

Note: **Malignant hypertension** is hypertensive emergencies, occur when the BP elevation is >180 mm Hg systolic and/or >120 mm Hg diastolic with evidence of end-organ damage (retinopathy, stroke, renal failure or MI) that should be corrected within 24 hr of presentation while **benign hypertension** may be asymptomatic for long time and take chronic course

Pathological changes of hypertension

1. Hypertension accelerates ATH & induces degenerative changes in wall of large & medium size arteries.

2. Hypertension in small vessels is associated with two forms of vascular diseases:

I. Hyaline arteriolosclerosis:

- Can be seen in **normotensive patients**, but it is **more severe in**
- **hypertensive (benign) patients and in diabetic patients**
- Vascular lesion **consists of a homogeneous, pink hyaline** thickening of the walls of arterioles & narrowing of lumen.
- This hyaline thickening is due to leakage of plasma components across vascular endothelium & also due to excess extracellular matrix production by the SMC_s as response to hypertension.
- Hyaline arteriolosclerosis is diffuse process; it is typically seen in benign nephrosclerosis which result from chronic hypertension, the arteriolar narrowing causes diffuse impairment of renal blood supply and glomerular scarring.

- **Hyperplastic Arteriolosclerosis:**
  - Characteristic of **malignant hypertension** (diastolic blood pressure above 120 mm Hg).
  - Vascular lesion characterized by **onion-skin, concentric, laminated thickening of the walls of arterioles with progressive narrowing of lumen (this lamination under electron microscope is consist of SMC, thickened basement membrane).**
  - Hyperplastic lesion **is accompanied by fibrinoid necrosis of the vessel walls, mainly seen in the kidney.**

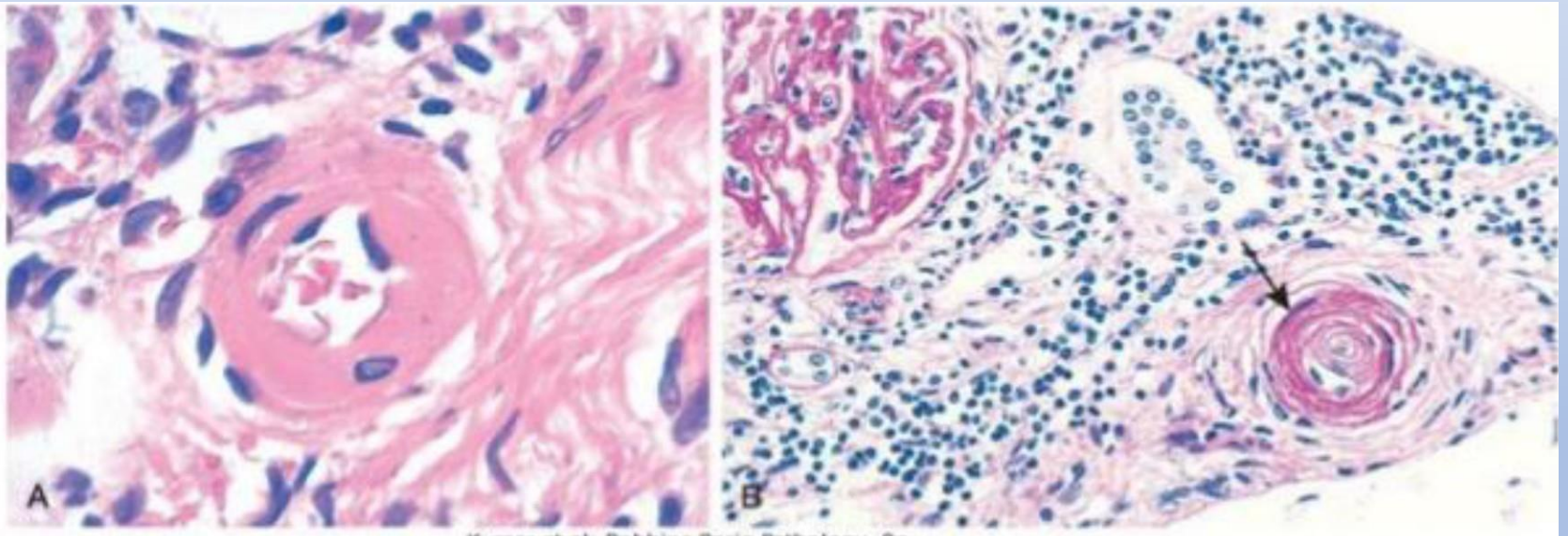
Normal

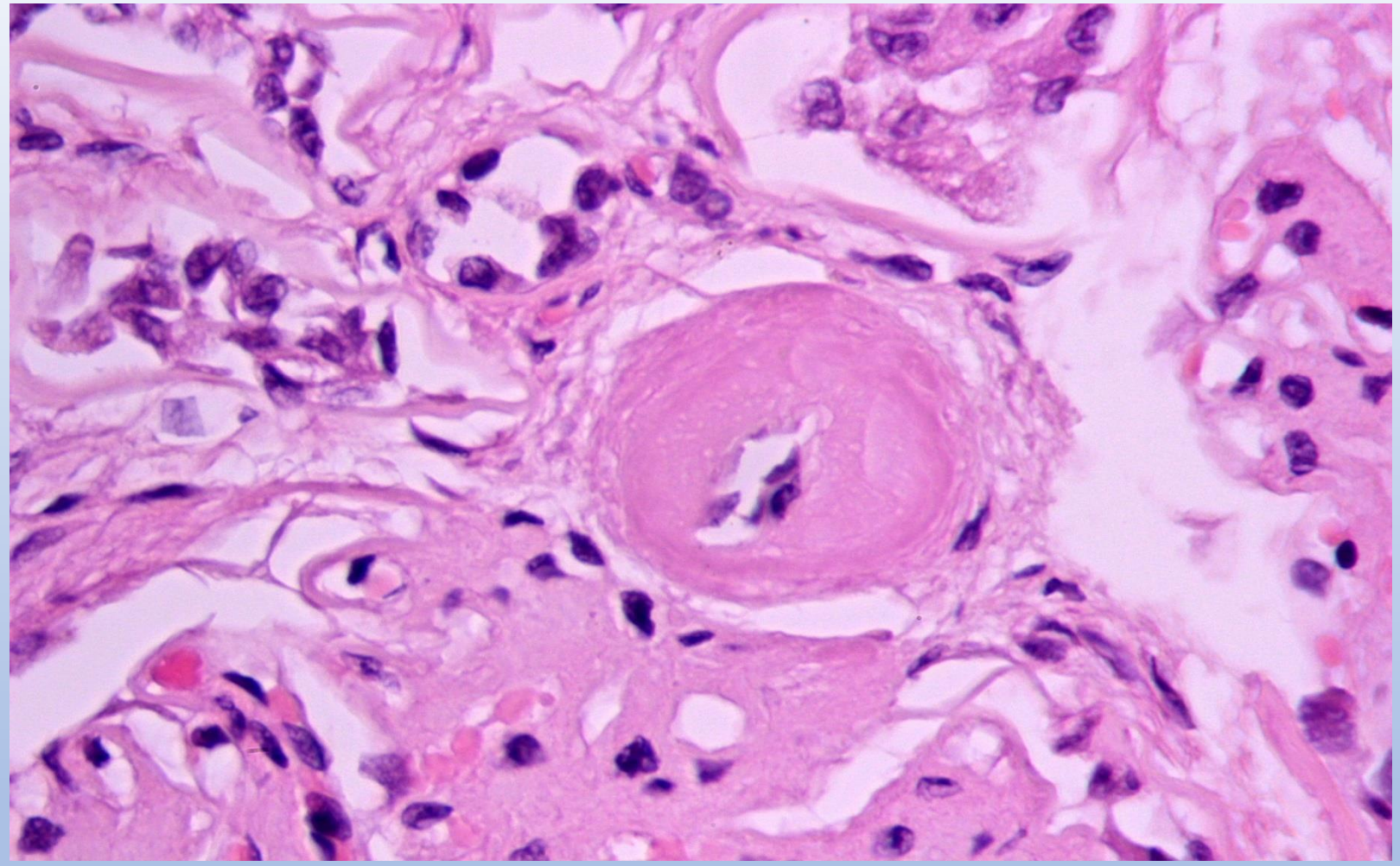
Hyaline arteriolosclerosis

Hyperplastic arteriolosclerosis

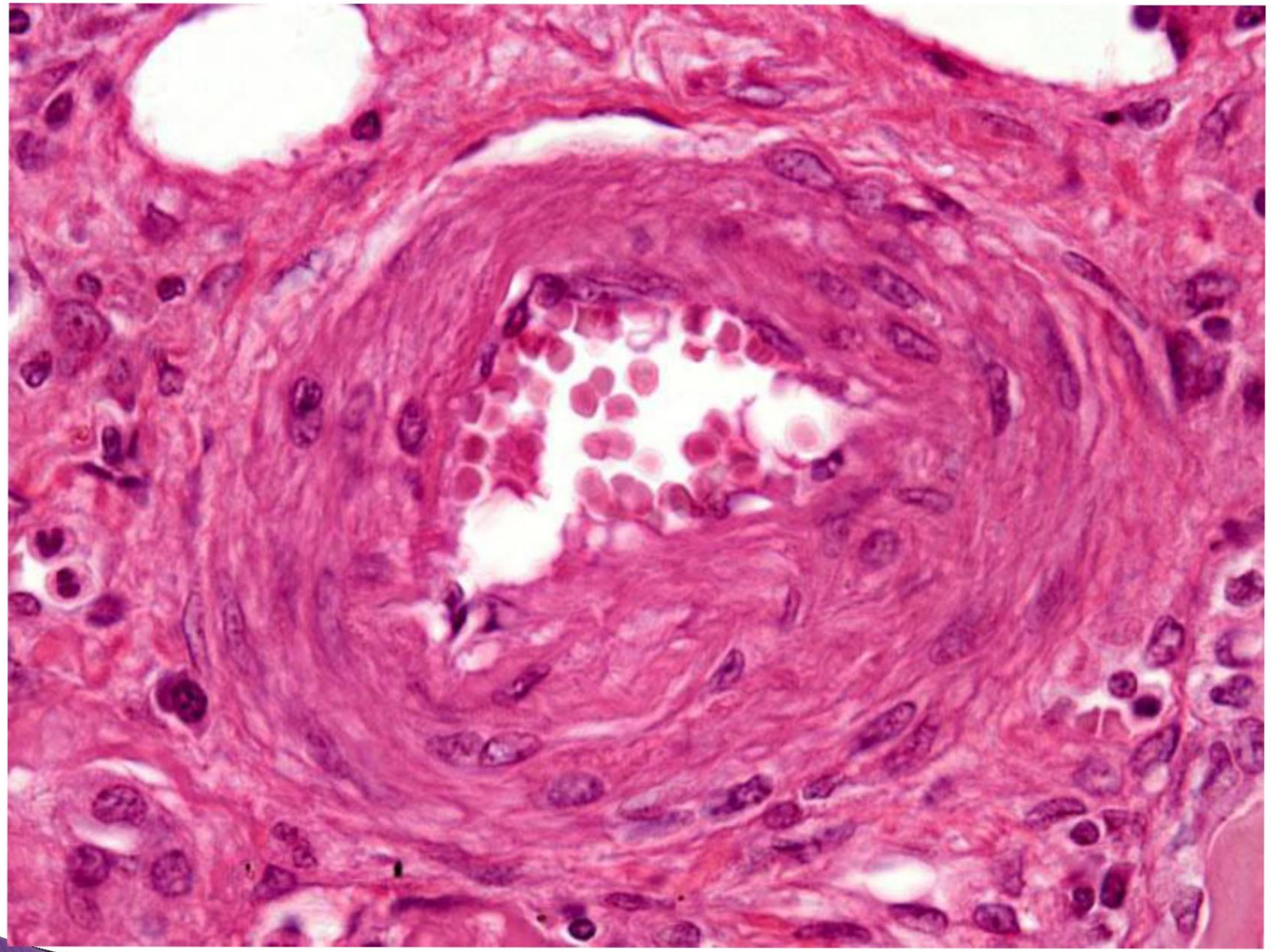
A, Hyaline arteriolosclerosis. The arteriolar wall is thickened with the deposition of amorphous proteinaceous material, and the lumen is markedly narrowed.

B, Hyperplastic arteriolosclerosis ("onion-skinning") *(arrow)* causing luminal obliteration

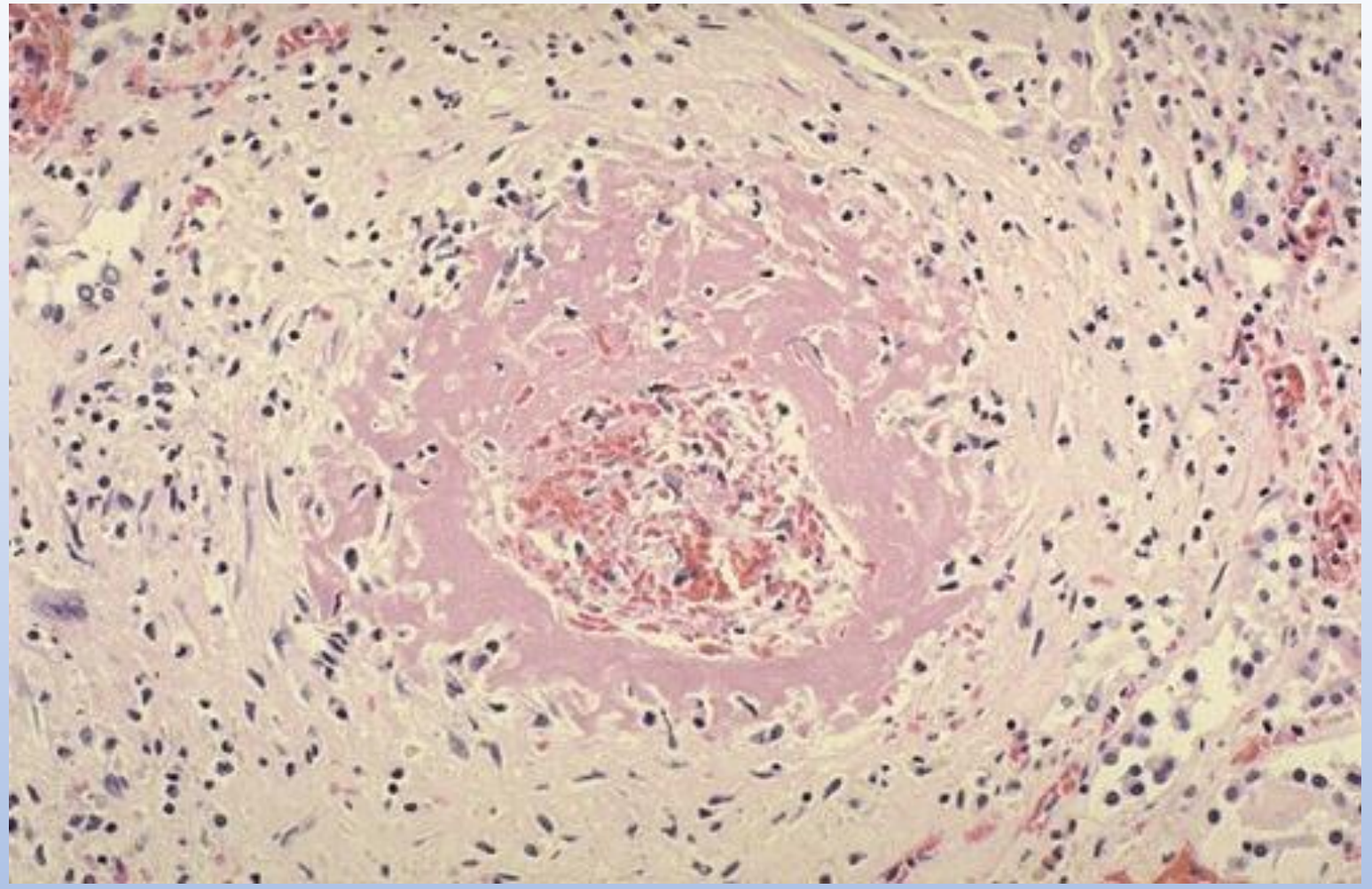




Hyaline arteriolosclerosis



-.....!Hyperplasic arteriolosclerosis

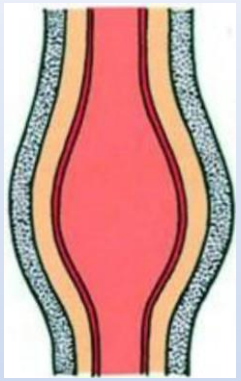


One complication of hyperplastic arteriolosclerosis with hypertensive emergency (malignant hypertension) , **fibrinoid necrosis**, as seen here involving a renal arteriole.

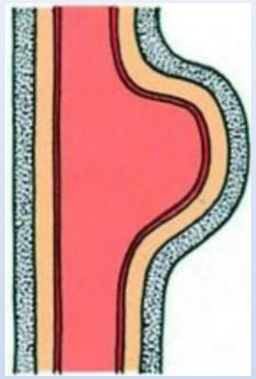
- Aneurysm and Dissection
- Aneurysm
- An aneurysm is a localized abnormal dilation of a blood vessel or the heart; it can be congenital or acquired.
- When an aneurysm involves an intact attenuated arterial wall or thinned ventricular wall of the heart, it is called a true aneurysm.
- Examples on true aneurysm are Atherosclerotic, Syphilitic, & congenital vascular aneurysm
- In contrast, false aneurysm :(also called pseudo- aneurysm) is a defect in the vascular wall leading to an extravascular hematoma that freely communicates with the intravascular space (“pulsating hematoma”).

Examples on false aneurysm is ventricular rupture after myocardial infarction that is contained by a pericardial adhesion

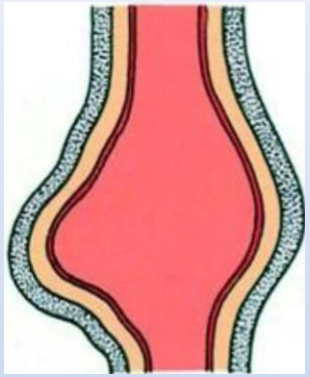
- **Aneurysms can be either saccular or fusiform**
  - **Saccular aneurysms** are spherical outpouchings (involving only a portion of the vessel wall); in intracranial vessels they generally measure 2 to 20 mm; however, in the aorta they range from 5 to 10 cm in diameter and often contain thrombus.
  - **Fusiform aneurysms** involve diffuse, circumferential dilation of a long vascular segment; they vary in diameter (in the aorta generally from 5 to 10 cm).
  - These types are not specific for any disease or clinical manifestations.



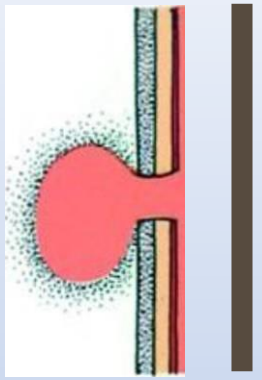
Fusiform aneurysm



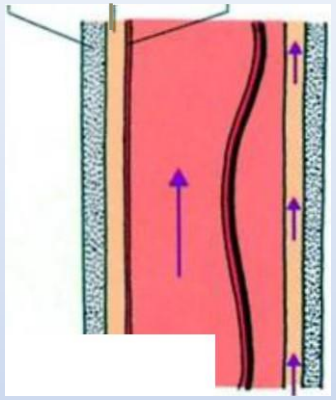
Saccular aneurysm



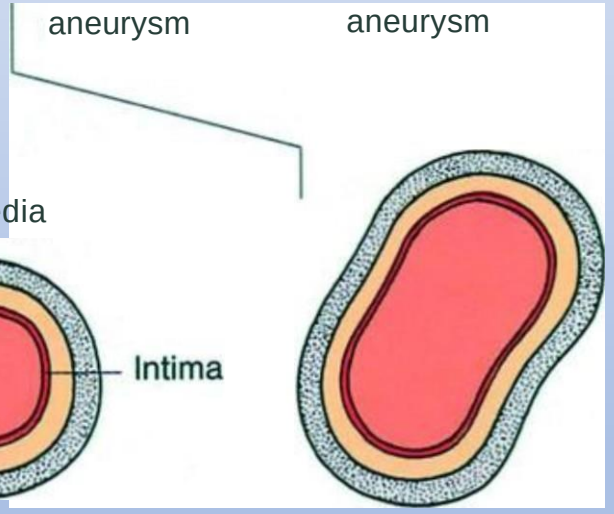
Fusiform/saccular aneurysm



False aneurysm

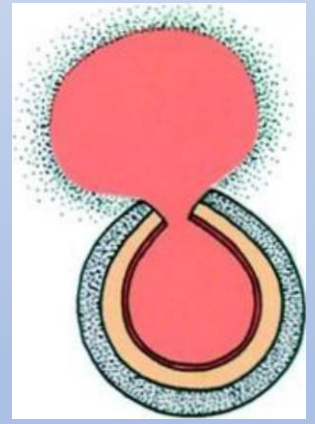


Dissection

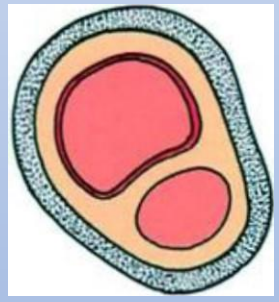


Normal arterial wall

True aneurysm



False aneurysm (pseudoaneurysm)



Dissection

Causes of aneurysm

The two most important causes of aortic aneurysms are

- **atherosclerosis and hypertension**.
  - Atherosclerosis is a greater factor in Abdominal Aortic Aneurysms (AAA).
  - While hypertension is the most common etiology associated with ascending aortic aneurysms.

Other pathologies and risk factors that weaken vessel walls and lead to aneurysms include **advanced age, smoking, trauma, vasculitis, syphilis, congenital defects** (e.g., fibromuscular dysplasia and berry aneurysms), and **infections (mycotic aneurysms)** which result from infection of the arterial wall.

Abdominal Aortic Aneurysms (AAA):

Site of AAA: Abdominal aorta usually below the renal arteries & above the bifurcation of the aorta.

- **Shape & size**: AAA is **saccular or fusiform**, up to 15 cm in diameter & up to 25 cm in length.
- **Sex:** more in the male.
- **Cause of AAA:**

1. Atherosclerosis (commonest)
2. Familial (associated with Hypertention)

- **3.** Marfan syndrome

Clinical Features:

- Most cases of AAAs are completely asymptomatic and are discovered incidentally on physical examination as an abdominal mass (pulsating mass) that simulates a tumor.
- Or it can present as complication :

1.Rupture into peritoneal cavity, or retroperitoneal tissue with massive, fatal hemorrhage.

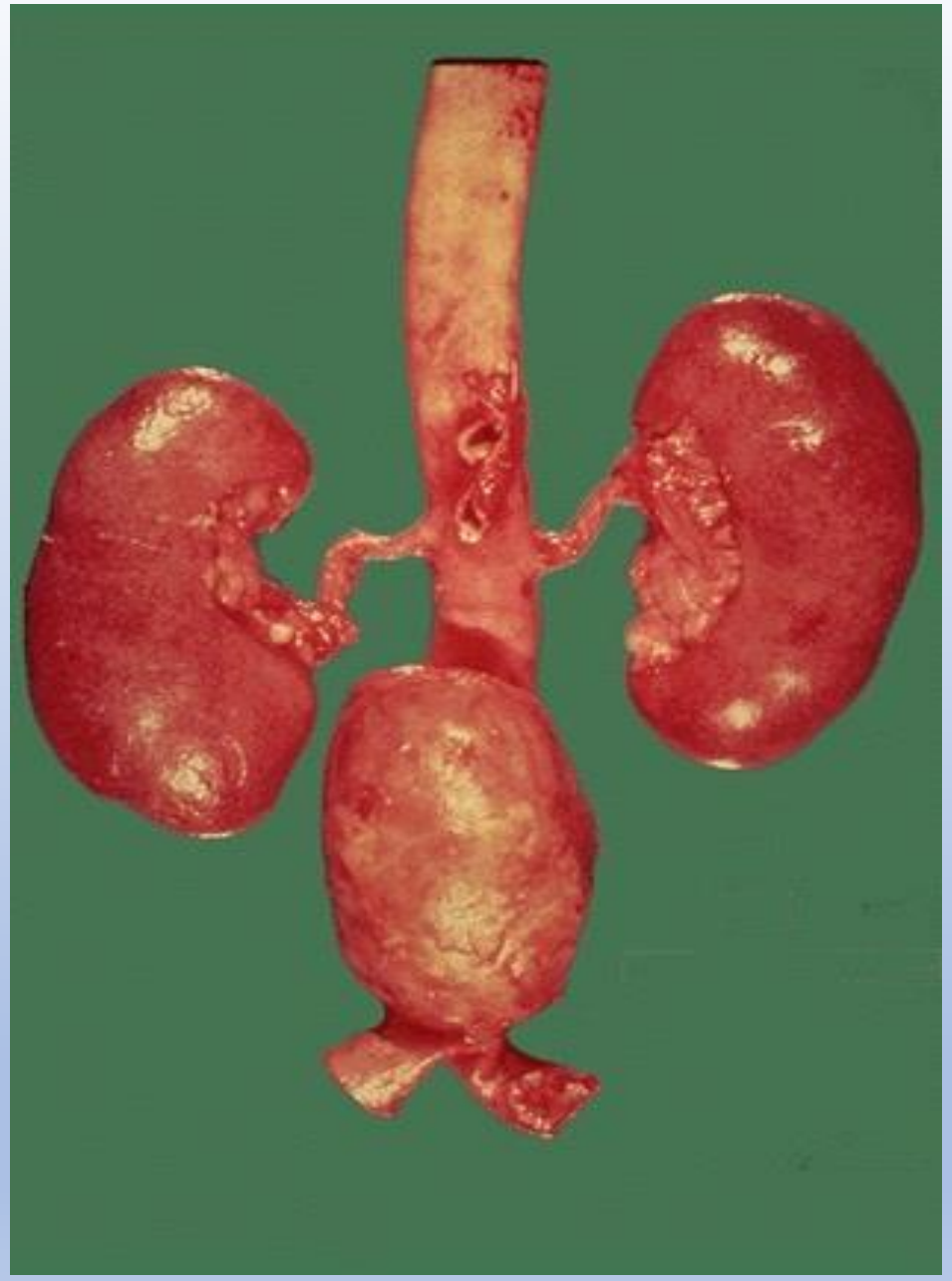
2. Obstruction of a vessel, particularly iliac, renal, mesenteric,

- or vertebral branches that supply the spinal cord.

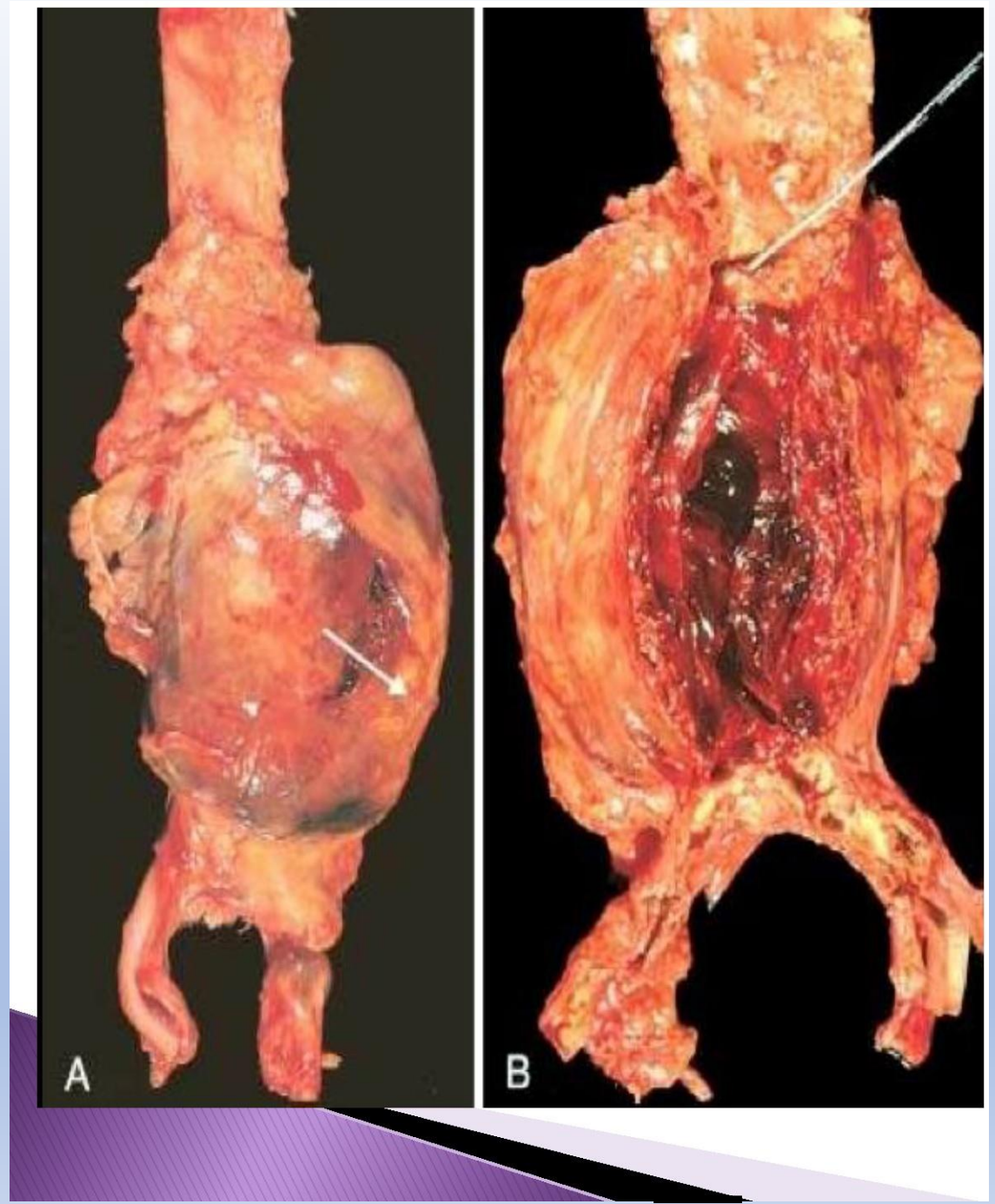
3.Embolization from atheroma or mural thrombus formed within the aneurysm.

4. Compression of adjacent organs, compression of a ureter or erosion of vertebrae.

- The risk of rupture is directly related to the size of the aneurysm.



Here is an example of an atherosclerotic aneurysm of the aorta in which a large "bulge" appears just above the aortic bifurcation . Such aneurysms are prone to rupture when they reach about 6 to 7 cm in size.



Abdominal aortic aneurysm.

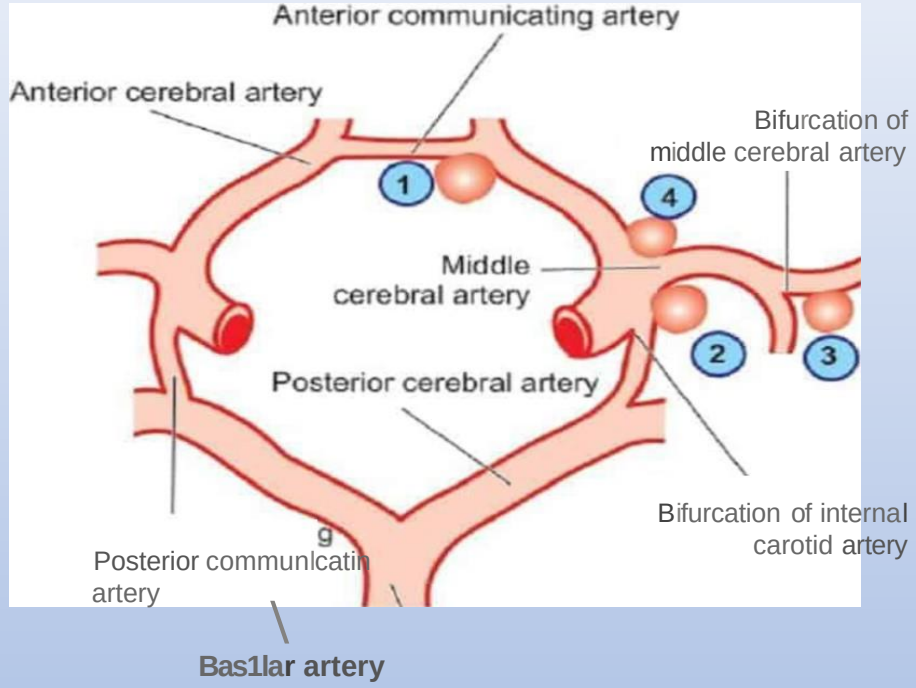
A gross photograph of a large aortic aneurysm that ruptured; the rupture site is indicated by the *arrow.* B, Opened view, with the location of the rupture tract indicated by a probe.

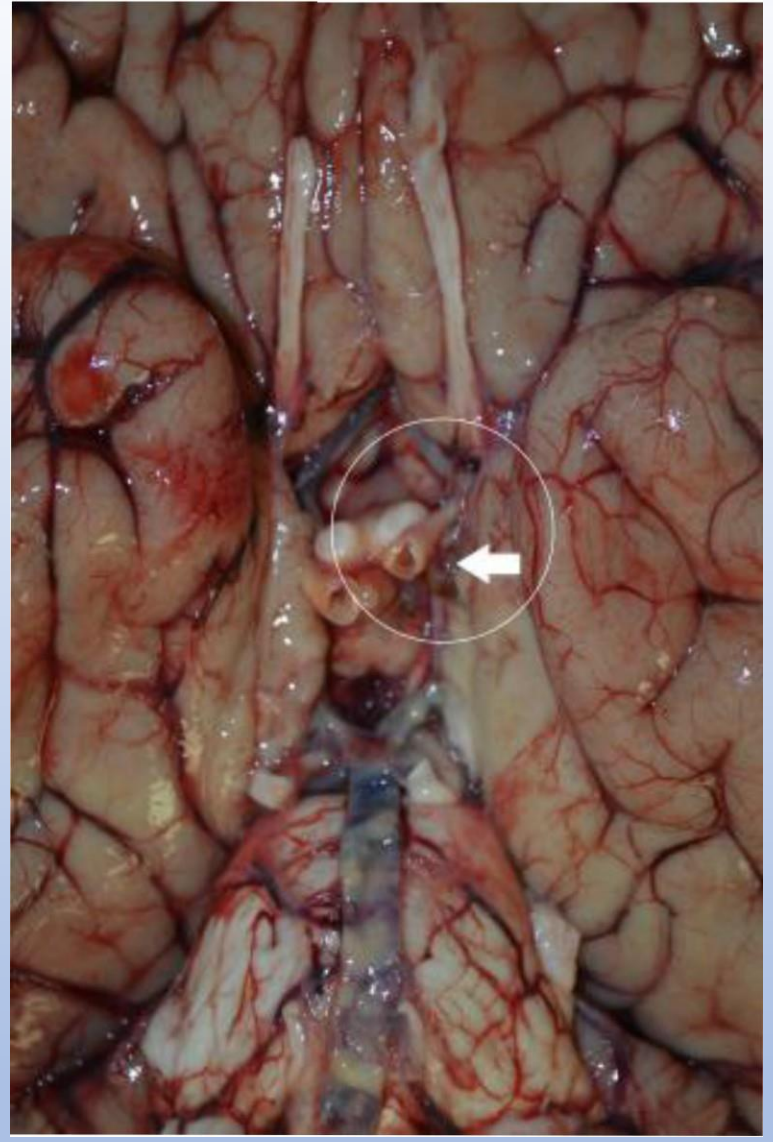
- **Thoracic Aortic Aneurysm**
- Thoracic aortic aneurysms are most commonly associated with hypertension, although other causes such as Marfan syndrome and inflammatory conditions (aortitis) are increasingly recognized.
- Most of these aneurysms are asymptomatic until dissection or rupture but symptoms could includes :

- Chest pain from bone erosion
- Myocardial ischemia from compression of a coronary artery
- Difficulty in swallowing due to compression of the esophagus
- Hoarseness of voice from pressure on the recurrent laryngeal nerves
- Respiratory complications from compression of the bronchi

Berry Aneurysm

- This congenital aneurysm is the most frequent type of intracranial aneurysms (90%) and the one most frequently responsible for subarachnoid hemorrhage.
- It has an incidence of about 2% in the general population.
- An unruptured berry aneurysm is a thin-walled bright red out-pouching at arterial branch points along the circle of Willis or major vessels just beyond.
- The pathogenesis is thought to be due to congenital defect of the media especially at bifurcations.
- Ruptured berry aneurysm with clinically significant subarachnoid hemorrhage is most frequent in the age group of 40-50 years

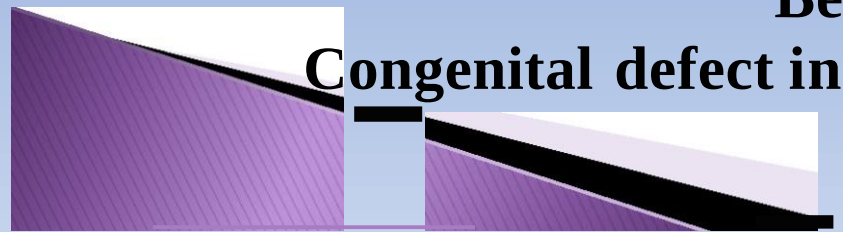




The circle of Willis showing principal sites of berry (saccular) aneurysms . The serial numbers indicate the frequency of involvement.

Berry aneurysm

Congenital defect in the media of vessels of circle of willis



Aortic Dissection

- **Aortic dissection occurs when blood enter the wall of a vessel through an intimal tear and dissects (separate) through the lamellar layers to form a blood-filled channel within the aortic wall.**
- Aortic dissection can be disastrous if the dissection then ruptures through the adventitia and hemorrhages into adjacent spaces

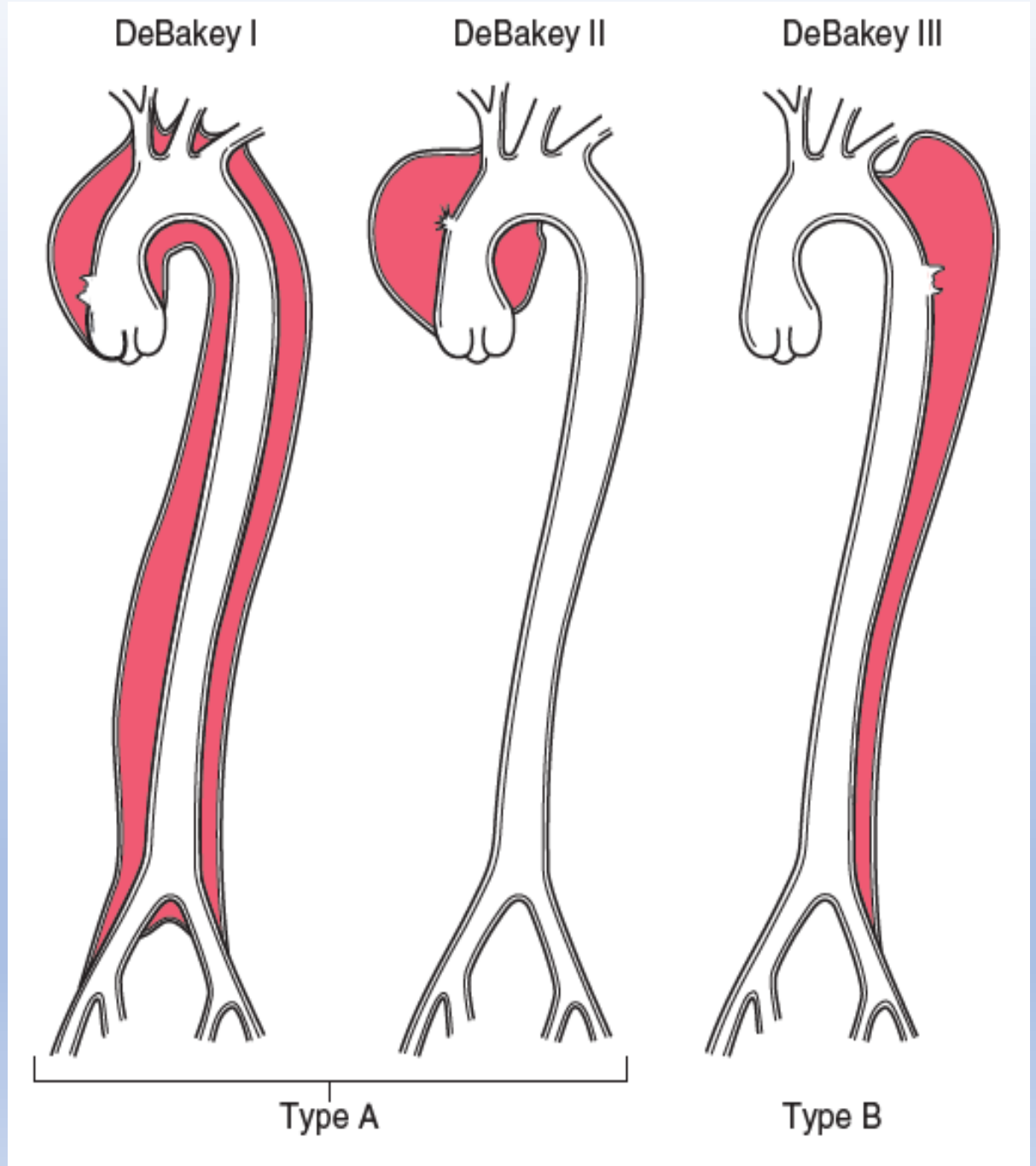
This dissection of the aorta occur principally in two groups of patients

1 Hypertensive men (90 % of the cases)

2 In those with a systemic or localized abnormality of connective tissues that affects the aorta (e.g. Marfan syndrome) (10% of the cases), the patients are usually younger than the above group.

- Dissection is unusual in the presence of atherosclerosis or other cause of medial scarring, such as syphilis, because the medial fibrosis inhibits propagation of the dissecting hematoma

- **Classification of aortic dissection:**
- **Type A dissections.** These are the more common (and dangerous) proximal lesions involving either both the ascending and the descending aorta or the ascending aorta only (DeBakey type I and II).
- **Type B dissections**. Distal lesions not involving the ascending aorta and usually beginning distal to the subclavian artery (DeBakey type III).


DeBakey I
DeBakey II
DeBakey III
Type A
Type B

- **Conditions associated with aortic dissection are**

1.Hypertension

2.Medial necrosis or degeneration of the aortic wall (as in Marfan’s syndrome)

3.Dissections can be iatrogenic (e.g., following arterial cannulations during diagnostic catheterization or cardiopulmonary bypass)

4.Previous surgery to the aorta e.g. coronary bypass or aortic valve replacement

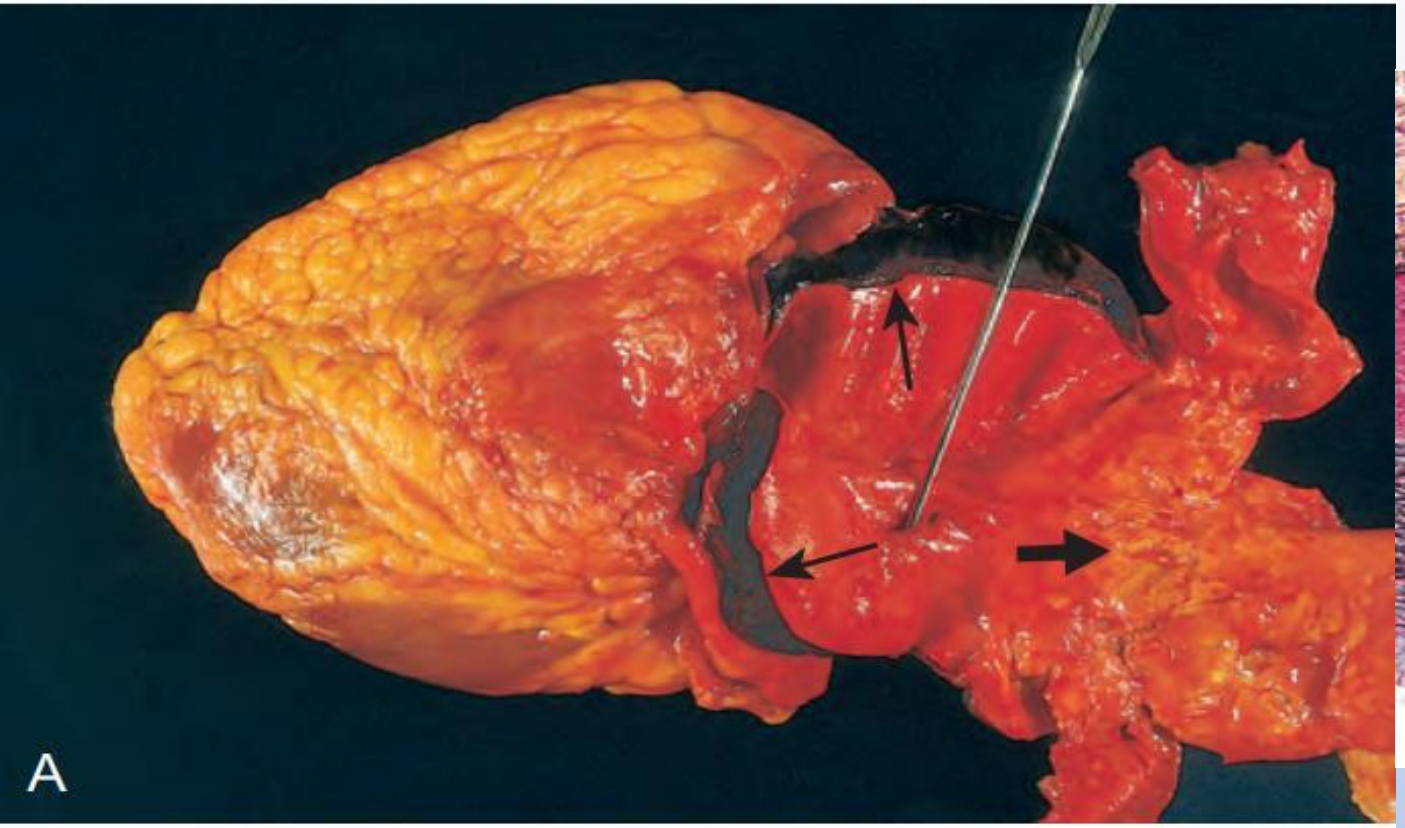
5.Pregnancy associated with aortic dissection (about 10 to 20 cases per 1 million births) typically occurring during or after the third trimester, it may be related to hormonally induce hemodynamic stresses of the perinatal period.

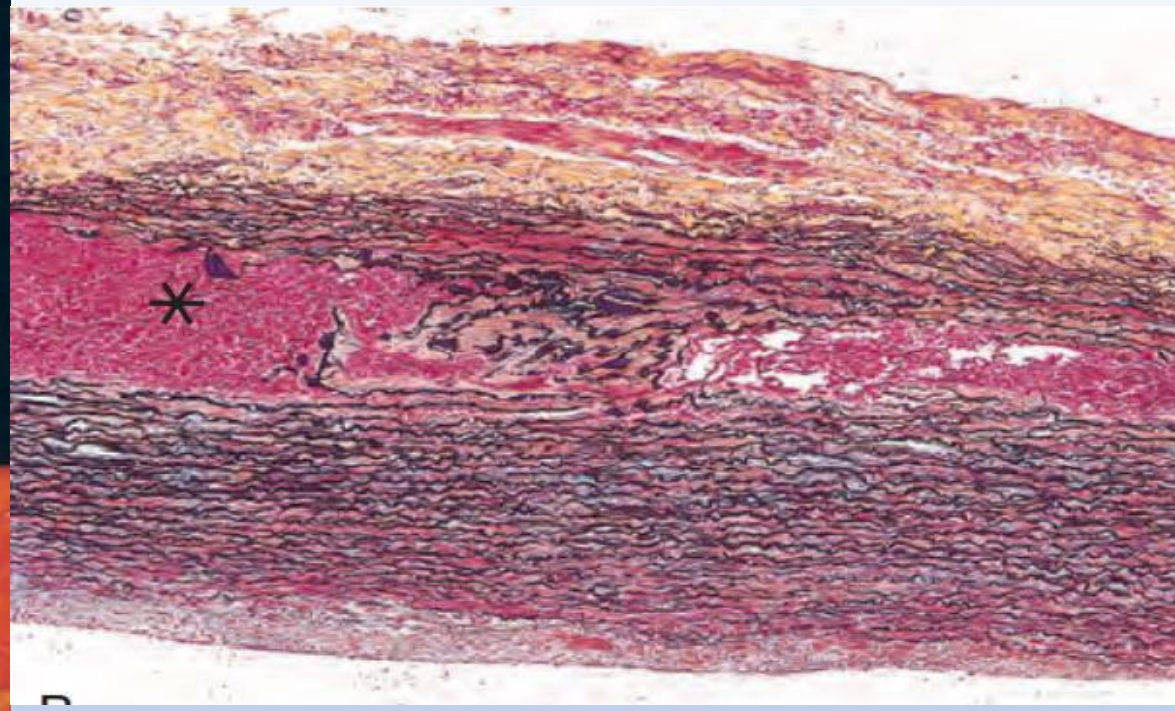
- **Mechanisms of Aortic Dissection:**
  - An aortic dissection usually initiates with an **intimal tear**, the tear occurs in the ascending aorta, usually within 10 cm of the aortic valve , such tears are typically transverse with sharp, jagged edges up to 1 to 5 cm in length.

- **Clinical features of aortic dissection:**
- Sudden onset of severe pain, usually at the anterior chest, then radiate to back, & moving downward with direction of dissection, (differential diagnosis is myocardial infarction).

- **Aortic dissection may have the following consequences**

1. Rupture into any of the three body cavities i.e. pericardial, pleural or peritoneal , this is the most common cause of death.
2. Extension of the dissection into the great arteries of the neck, coronaries, renal, mesenteric, or iliac arteries , this leads to their obstruction with subsequent ischemic damage to the relevant organs e.g. myocardial infarction, renal infarction
3. Retrograde dissection into the aortic root that leads to disruption of the valvular apparatus with consequent aortic valve insufficiency.





Aortic dissection. (A) Gross photograph of an opened aorta with proximal dissection originating from a small, oblique intimal tear (probe), allowing blood to enter the media and creating a retrograde intramural hematoma (thin arrows). Note that the intimal tear has occurred in a region largely free of atherosclerotic plaque and that propagation of the intramural hematoma distally is arrested where atherosclerosis begins (thick arrow). (B) Histologic view of dissection demonstrating an aortic intramural hematoma (asterisk). Aortic elastic layers are black and blood is red (Movat stain).

Thank you