VASCULAR PATHOLOGY

ARTERIES	ARTERIOLES	CAPILLARIES	VENOUS	LYMPHATICS
Intima: lined by endothelial cells; minimal subendothelial connective tissue **Media**: concentric layers of smooth muscle cells (SMCs); separated from the intima by the **internal** elastic lamina & separated from adventitia by **external** elastic lamina **Adventitia:** connective tissue (collagen), nerve fibers, vessels – *vaso vasorum* – supply out ½ to 2/3 of wall ELASTIC ARTERIES – Media rich in elastic fibers – Expands in systole, recoils in diastole – Aorta & large branches – **Age**: loss of elasticity (becomes stiffer) → loss of compliance → increased systolic blood pressure MUSCULAR ARTERIES – Media rich in SMCs – Other branches of aorta (i.e. coronary & renal arteries)	Smallest branch of arteries Principle point of *physiologic resistance to blood pressure* – Sharply reduce pressure & velocity – Changes flow from pulsatile to steady	Diameter of a RBC Endothelial lining, no media or adventitia Very large cross-sectional area	POST-CAPILLARY VENULES – Drain capillary beds – Preferred site from many types of inflammation VEINS (compared to arteries) – Larger lumens, thinner walls, valves to prevent reverse flow	Thin-walled Endothelium-lined vessels with NO RBCs Drain interstitial fluid, lymph is created Can disseminate disease

CONGENITAL ANOMALIES

- ARTERIOVENOUS FISTULA
  - Abnormal communication between arteries & veins *(blood flows from artery → vein, bypassing capillaries)*
  - **Caused by**: *developmental defect (most common)*, penetrating injuries piercing the artery wall & vein, rupture of an arterial aneurysm into vein, inflammation necrosis of adjacent vessels, or created intentionally as vascular access for hemodialysis
  - AV fistulas can rupture – *this is why it is serious if it occurs in the brain*
- FIBROMUSCULAR DYSPLASIA
  - Focally thickened segments due to medial & intimal hyperplasia & fibrosis that results in luminal **stenosis** (narrowed vessel wall) and/or aneurysms between the thickened segments
  - It is an uncommon form of vascular obstruction involving medium-sized muscular arteries. ***The renal arteries are most often affected & are one of the surgically correctible causes for HTN.***
  - Looks like "beads on a string"

ENDOTHELIAL CELL S

- Endothelial cells function to maintain normal vessel homeostasis
  - Non-thrombogenic blood-tissue interface
  - Modulate vascular resistance
  - Metabolize hormones
  - Regulate immune & inflammatory reactions
  - Affect growth of other cells, especially SMCs
- Tight endothelial junctions (so they can control what is coming into & out of vessels) normally exists, but they can loosen
  - **Affected by:** hemodynamic factors (i.e. HTN) & vasoactive agents (i.e. histamine)
  - **Results:** loss of electrolytes & proteins into tissues, escape of leukocytes in **inflammation**
    - ***Inflammation results in fibrosis, which can contribute to organ ischemia***

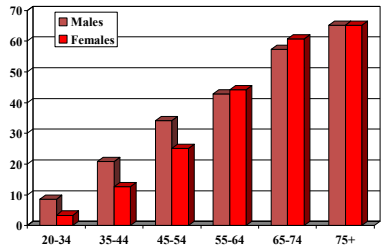
ENDOTHELIAL CELL RESPONSE TO INJURY: ACTIVATION or DYSFUNCTION

- **ACTIVATION**
  - Expression of inducible properties, induced by many factors, including:
    - Cytokines, bacterial products, hemodynamic stresses (HTN), lipid products (hypercholesteremia), & glycosylation end products (i.e. diabetes)
  - Results in expression of adhesion molecules & the production of cytokines, chemokines, vasoactive molecules, pro- & anticoagulants, etc.
- **DYSFUNCTION**
  - Impairs vasoreactivity & induces thrombogenic or abnormally adhesive surface
  - May be rapid & reversible OR slower response (hours to days)
  - Contributes to **thrombus formation**, initiation of atherosclerosis, vascular effects of HTN & other disorders

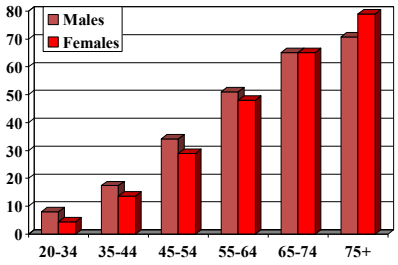
VASCULAR SMOOTH MUSCLE

- Normal vascular repair
- Migration & proliferation regulated by growth promoters & inhibitors
- Synthesis of collagen, elastin, & proteoglycans (ECM)
- Vasoconstriction & dilation
- **RESPONSE TO INJURY: PATHOLOGY**
  - Vascular injury may be associated with endothelial loss or dysfunction, may be mechanical (*angioplasty*), immunologic (*transplant arteriosclerosis*), or multifactorial (*atherosclerosis*)
  - **INTIMAL THICKENING**
    - Stereotypical response to vascular injury regardless of the cause; can cause stenosis or occlusion of small & medium-sized vessels
    - Form a new intima (neointima), covered with endothelial cells
    - **Endothelial cells** – migrate into intima from adjacent uninjured areas OR derived from circulating precursors
    - **Smooth muscle cells** – migrate into intima from media or circulating precursors; *proliferate*, synthesize ECM; neointimal SMCs express a *proliferative* rather than contractile phenotype

HYPERTENSION – PREVALENCE



CARDIOVASCULAR DISEASE – PREVALENCE



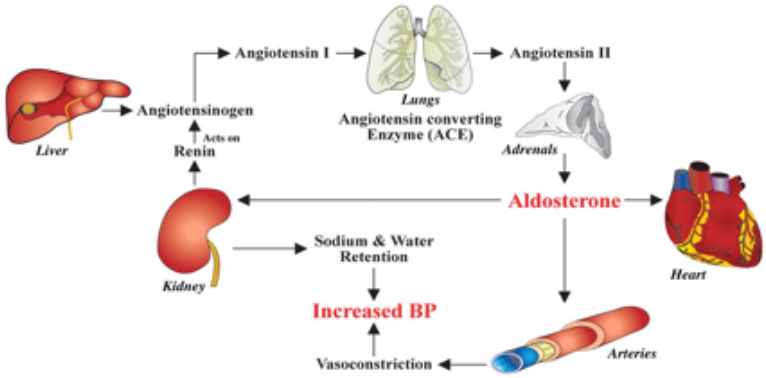
HYPERTENSIVE VASCULAR DISEASE

- Normal factors that influence blood pressure
  - Age: *loss of elasticity in vessels as you age (↑SBP)*
  - Gender
  - BMI
  - Diet (especially sodium intake)
- **Blood pressure is determined by 2 hemodynamic variables:**
  - **CARDIAC OUTPUT = SV x HR**
    - **Stroke volume**
      - Filling pressure or blood volume, which is dependent on body Na^+
      - Contractility: regulated by α and β adrenergic systems
    - **Heart rate**: regulated by α and β adrenergic systems
  - **TOTAL PERIPHERAL VASCULAR RESISTANCE**
    - Controlled at the level of the **arteriole** – *primary morphologic site of blood pressure regulation in the vascular system*
    - Balance between vasoconstrictors & vasodilators
    - **AUTOREGULATION:** ↑ blood volume causes arteriole constriction to control tissue perfusion; other local factors: pH, hypoxia

BLOOD PRESSURE CLASS	SBP mmHg	DBP mmHg
Normal	< 120	< 80
Pre-HTN	120-139	80-89
Stage 1	140-159	90-99
Stage 2	> 160	> 100

HYPERTENSIVE VASCULAR DISEASE & THE KIDNEY

- The kidney influences both peripheral resistance & cardiac output through sodium homeostasis
- Renin-angiotensin system with eventual formation of **angiotensin II** (in the lung)
  - ↑ peripheral resistance (by vasoconstriction, acts on SMCs)
  - ↑ blood volume (via aldosterone which ↑ Na^+ reabsorption in distal tubules → water retention!)



- Vascular relaxing substances: prostaglandin, NO
- ↓ glomerular filtrate rate (GFR) from ↓volume → ↑reabsorption of Na^+ in proximal tubules → ↑ blood volumes
- **Natriuretic factors**: Atrial & ventricular
  - Released in response to volume expansion & dilation of cardiac chambers
  - Inhibit Na^+ reabsorption in distal tubules
  - Induce vasodilation

HYPERTENSION: Systolic > 139 mmHg & Diastolic > 89 mmHg

- PRIMARY (ESSENTIAL) HYPERTENSION
  - Etiology unknown
  - Accounts for 90-95% of cases in HTN -- ~25% of population
  - Mechanism:
    - **Genetic Factors**
      - Single gene disorders cause rare forms
      - Polymorphisms in several genes have cumulative effect on blood pressure
      - Predisposition is associated with variations in genes encoding **components of renin-angiotensin system**
      - Genetic variants in renin-angiotensin system may contribute to known racial differences in incidence of HTN
    - **REDUCED RENAL Na^+ EXCRETION**
      - May be initiating event in essential HTN
      - Starts at normal arterial pressure
      - ↓Na^+ excretion → ↑plasma volume → ↑cardiac output & peripheral vasoconstriction→ ↑BP
      - Higher BP → ↑Na^+ excreted, so now it equals Na^+ intake so no further fluid retention
        - New steady state of Na^+ excretion, but at a higher BP
    - **Factors that induce vasoconstriction ↑peripheral vascular resistance**
    - **Environmental Factors**
      - Stress, obesity, cigarette smoking, physical inactivity, dietary sodium intake
- SECONDARY HYPERTENSION – Causes:
  - **RENOVASCULAR DISEASE – Renal Artery Stenosis**
    - Due to atherosclerosis (*elderly males)* or fibromuscular dysplasia (*young female)*
    - **Mechanism**: decreased glomerular flow stimulates renin-angiotensin-aldosterone system
  - **ENDOCRINE DISORDERS**
    - Primary aldosteronism, Cushing syndrome, pheochromocytoma, hyperthyroidism
  - OTHER
    - Coarctation of aorta, toxemia of pregnancy, CNS disorders, drugs & chemicals
- MALIGNANT HYPERTENSION (Sys > 200, Diast > 110)
  - Usually a complication of either essential or secondary HTN
  - Clinically follows an **ACCELERATED** course
  - **Results**: renal failure, retinal hemorrhages, death in 1-2 years if untreated

RESULTS OF UNTREATED HYPERTENSION

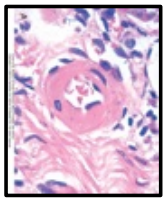
- Atherosclerosis
- Degenerative changes in vessel walls causing aortic dissection, cerebrovascular hemorrhage, multi-infarct dementia
- Retinal changes
- Left ventricular hypertrophy & heart failure
- Benign **nephrosclerosis** (hyaline arteriolosclerosis of kidneys) causes diffuse renal ischemia & symmetric shrinkage

BENEFITS OF LOWERING BLOOD PRESSURE

- Decrease stroke risk by 35-40%
- Decrease MI risk by 20-25%
- Decrease CHF risk by >50%!

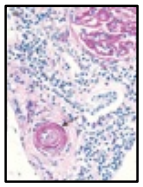
***ARTERIOLOSCLEROSIS**: Hardening of the arterioles*

****HYALINE ARTERIOLOSCLEROSIS**:



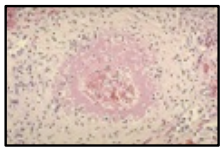
- *Increased protein is deposited in the vessel wall & occludes the lumen*
- *Often caused by **DM & HTN** (increased intraluminal pressure in arterioles pushes plasma proteins into the vessel wall)*
- Homogenous, pink, hyaline thickening of walls & arterioles
- From leakage of plasma protein across injured endothelium
- Increases smooth muscle cell matrix synthesis
- Narrows lumen
- In kidneys: **nephrosclerosis** – scarring of glomerulus secondary to impaired renal blood supply → *chronic renal failure*
- *Seen in **mild chronic HTN***

****HYPERPLASTIC ARTERIOLOSCLEROSIS**



- *Acute increase in BP (i.e. malignant HTN) causes basement membrane duplication & smooth muscle hyperplasia in the renal arterioles (i.e. afferent & efferent arterioles)*
- "**Onion-skin**," concentric, laminated thickening of the arteriole walls
  - **Layers of smooth muscle cells**
  - Thickened & reduplicated basement membrane
- **Progressive narrowing of the lumen**
- *Seen in severe & **malignant HTN***

****FIBRINOID NECROSIS**

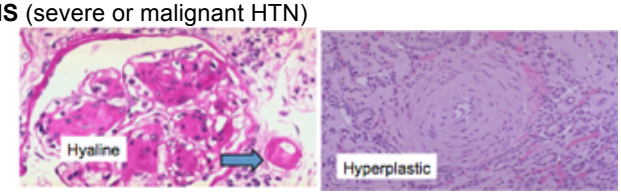


- Sometimes the small arteries & arterioles can be damaged so severely in malignant HTN that they demonstrate necrosis with a pink fibrin-like quality that gives this process its name – ***FIBRINOID NECROSIS***
- *Fibrinoid necrosis seen in HTN & vasculitis*

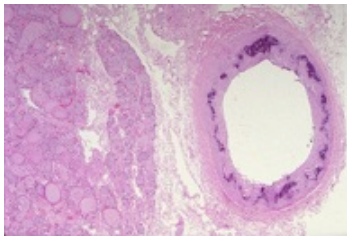
ARTERIOSCLEROSIS

ARTERIOSCLEROSIS: "hardening of the arteries"
- Arterial wall thickening
- Loss of elasticity
- **Three general patterns**: (1) *arteriolosclerosis, (2) Monckeberg medial sclerosis, (3) atherosclerosis*

1. ARTERIOLOSCLEROSIS: *Previous page*
- Small arteries & arterioles, *especially renal*
- Associated with HTN & DM
- Two variants: **HYALINE ARTERIOLOSCLEROSIS** (mild, chronic HTN) & **HYERPLASTIC ATERIOLOSCLEROSIS** (severe or malignant HTN)



2. MONCKEBERG ARTERIOSCLEROSIS
- Ring-like calcifications in the **MEDIA** of the muscular arteries (i.e. ulnar & radial)
  - NO CLINICAL SIGNIFICANCE!
- Patients older than 50 years
- Palpable, seen on x-ray
- Does not obstruct arterial flow
- May coexist with atherosclerosis but distinct from & unrelated to it



3. ATHEROSCLEROSIS – thickening of the INTIMA of the wall
- **MOST IMPORTANT & CLINICALLY SIGNIFICANT –** Responsible for ½ of all deaths in the Western world
- Characterized by intimal lesions called atherosclerotic plaques; primarily in elastic & muscular arteries
- Cause is multi-factorial
- **CONSTITUTIONAL RISK FACTORS**: same as for ischemic heart disease (IHD)
  - **Age**: risk increases with age
  - **Gender**: premenopausal woman are relatively protected; men & postmenopausal women at higher risk
  - **GENETIC**: *most important*, independent risk factor, multifactorial
- **MODIFIABLE RISK FACTORS**
  - **Hyperlipidemia**
    - **LDL** (Low Density Lipoprotein): "bad cholesterol;" major component of serum cholesterol associated with increased risk; form of cholesterol delivered to the tissues; raised by dietary intake of cholesterol, saturated fats, (trans)-unsaturated fats; lowered by omega-3 fatty acids, statins
    - **HDL** (High Density Lipoprotein): "good cholesterol;" higher levels correlate with decreased risk; mobilizes cholesterol from tissue & transports it to liver for excretion in bile; raised by exercise & EtOH in moderate amounts; lowered by obesity, smoking, & sometimes statins
  - ****HYPERTENSION**: major risk factor (all ages); SBP & DBP both important; increases risk of IHD by 60%
  - **Cigarette smoking**: prolonged smoking of >1ppd doubles risk
  - **Diabetes mellitus**: induces hypercholesterolemia; incidence of MI is twice as high in DM than non-DM
- **OTHER RISK FACTORS**
  - **Inflammation:** CRP is a marker of inflammation – acute phase reactant; predicts risk of MI, stroke, peripheral artery disease; reduced by smoking cessation, weight loss, exercise & statins
  - **Hyperhomocystinemia:** related to coronary artery disease, peripheral vascular disease, stroke, DVT
  - **Metabolic syndrome:** insulin resistance, HTN, central obesity; dyslipidemia **(↑LDL, ↓HDL)**; systemic proinflammatory state
  - **Lipoprotein A:** altered form of LDL containing apoB-100 portion of LDL linked to apoA
  - **Other factors:** sedentary lifestyle, lack of exercise, stressful lifestyle (type A), obesity

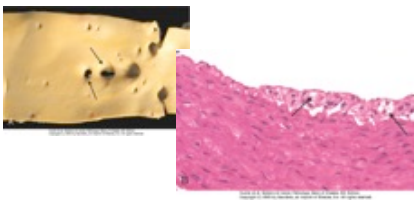
HTN, ↑LDL, ↓HDL, SMOKING, DM, RENAL FAILURE, SEX HORMONES, SEDENTARY LIFESTYLE = **ATHEROSCLEROSIS**

ATHEROSCLEROSIS: PATHOGENESIS

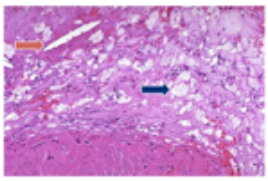
- *Atherosclerosis is a **chronic inflammatory & healing response of the arterial wall to endothelial injury**, known as the response-to-injury hypothesis*

1. **ENDOTHELIAL INJURY**
   - **Major causes**: hemodynamic disturbances (turbulence, **HTN**); hypercholesterolemia (↑LDL, ↓HDL, ↑lipoprotein a)
   - **Results in**: increased vascular permeability, leukocyte adhesion, thrombosis
2. **LIPOPROTEINS (LDL + oxidized forms)**
   - Lipoproteins move into vessel wall & trigger **inflammation** via production of **IL-1** → recruit monocytes & T cells
3. **MONOCYTES STICK TO INJURED ENDOTHELIUM**
   - Monocytes migrate into subendothelium where they transform into macrophages & foam cells
4. **PLATELETS STICK TO INJURED ENDOTHELIUM**
5. **FACTORS ARE RELEASED BY PLATELETS, MACROPHAGES, & VASCULAR WALL CELLS**
   - Induce smooth muscle cell recruitment – from media & circulating precursors
6. **SMCs PROLIFERATION & PRODUCE ECM**
   - SMCs are stimulated by PDGF from platelets, macrophages, endothelial cells & SMCs to produce ECM
7. **LIPID ACCUMULATES EXTRACELLULARLY & INTRACELLULAR (MACROPHAGES & SMCs)**

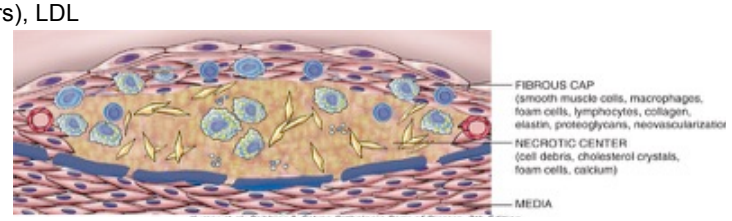
ATHEROSCLEROSIS: MORPHOLOGY

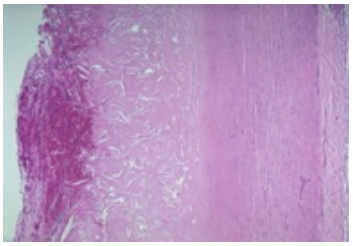


- FATTY STREAK!
  - Earliest lesion in atherosclerosis
  - **Composed of lipid-filled *foamy macrophages***; begin as fatty dots
  - Seen in some children younger than 1 y/o & all children by age 10
  - May be a precursor to plaques
- ATHEROSCLEROTIC PLAQUES
  - Intimal thickening, lipid accumulation (cholesterol & cholesterol esters), covered by a fibrous cap, lesions are patchy & eccentric
  - Flow disturbances increase susceptibility of certain areas of vessel wall
  - **DISTRIBUTION**: **ABDOMINAL AORTA** > THORACIC AORTA, more prominent around ostia
    1. **Lower abdominal aorta**
    2. **Coronary arteries**
    3. **Popliteal arteries**
    4. Internal carotid arteries
    5. Vessels of the Circle of Willis
  - **COMPONENTS**:
    - Cells – smooth muscle cells, macrophages, T cells
    - ECM – collagen, elastic fibers, & proteoglycans
    - Intracellular & extracellular lipids – foam cells (lipid-laden macrophages & SMCs contain cholesterol & cholesterol esters), LDL



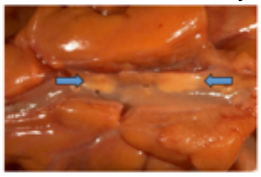
Many foam cells (blue) & a cholesterol cleft (red) are seen in this atheromatous plaque



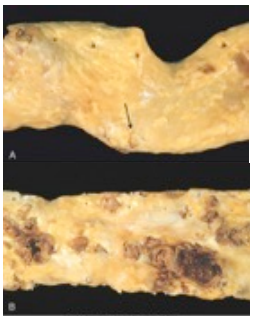


****ATHEROSCLEROTIC PLAQUES**

- Fibrous cap (subendothelial) composed of SMCs, collagen
- Beneath & to the side of cap ("shoulder" of the cap) – macrophages, T cells, SMCs
- Lipid core of cholesterol, foam cells, **NECROTIC** debris, & fibrin
- Periphery of plaque: neovascularization
- **IMAGE**: *Microscopically, the aortic atheromatous plaque is thicker than the remaining media at the right. The plaque contains amorphous pink material with slit-like "cholesterol cleft" of lipid material. There is overlying recent hemorrhage at the left. Thrombus may form on top of such a plaque.*
- Plaques are dynamic & may undergo remodeling—***Clinically significant changes:***
  - Patchy & massive calcification
  - Acute plaque change
  - Atheroembolism of disrupted plaque material
  - Aneurysmal formation: pressure of plaque weakens underlying vessel wall



MILD CORONARY ATHEROSCLEROSIS
A few scattered yellow lipid plaques are seen on the intimal surface of the opened coronary artery, transversing the epicardial surface of a heart. The degree of atherosclerosis is not significant enough here to cause disease, but could be the harbinger of worse atherosclerosis to come.

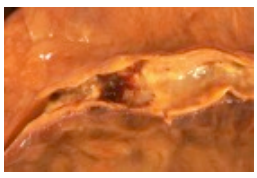


GROSS VIEW, ATHEROSCLEROSIS IN AORTA
Mild atherosclerosis composed of fibrous plaques (arrow)

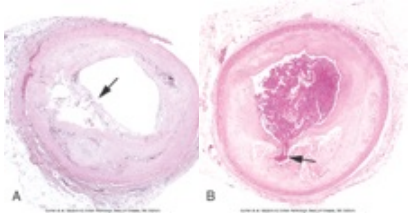
GROSS VIEW, ATHEROSCLEROSIS IN AORTA
Severe atherosclerosis with diffuse & complicated lesions with plaque rupture & superimposed thrombi

CONSEQUENCES OF ATHEROSCLEROSIS

- **Ischemic Heart Disease**: angina, MI, sudden cardiac death; stroke; ischemic bowel disease; peripheral vascular occlusive disease, gangrene of lower extremities; renal artery ischemia; aneurysm; *may be asymptomatic*
- **STENOSIS:** may gradually occlude smaller arteries
  - **"Critical" stenosis (~70% occlusion)** – chronic occlusion that significantly limits flow – inadequate perfusion; *symptomatic **on exertion**, until 90% occluded then symptoms at rest*; demand for O_2 exceeds supply; results in angina, mesenteric occlusion & bowel ischemia, chronic ischemic heart disease, & *intermittent claudication (PVD)*
  - *Atherosclerosis is generally worse at the beginning of an artery where turbulence is greater*
- **ACUTE PLAQUE CHANGE**
  - **Rupture/fissuring**: exposes thrombogenic plaque constituents
  - **Erosion/ulceration**: exposes thrombogenic basement membrane
  - **Hemorrhage into the plaque**: expands volume of the plaque
  - ***Both lead to thrombosis & vasoconstriction of the affected vessel***

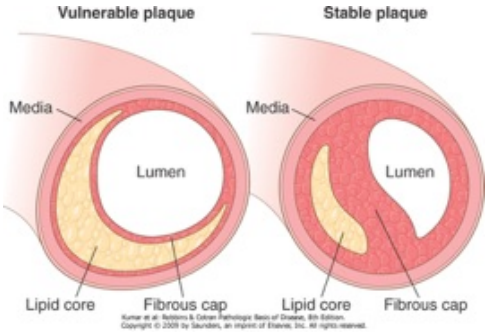


CORONARY ARTERY WITH ATHEROSCLEROTIC PLAQUES
There is *hemorrhage into the plaque* in the middle of the photo. This is one of the complications of atherosclerosis. Such hemorrhage could acutely narrow the lumen.



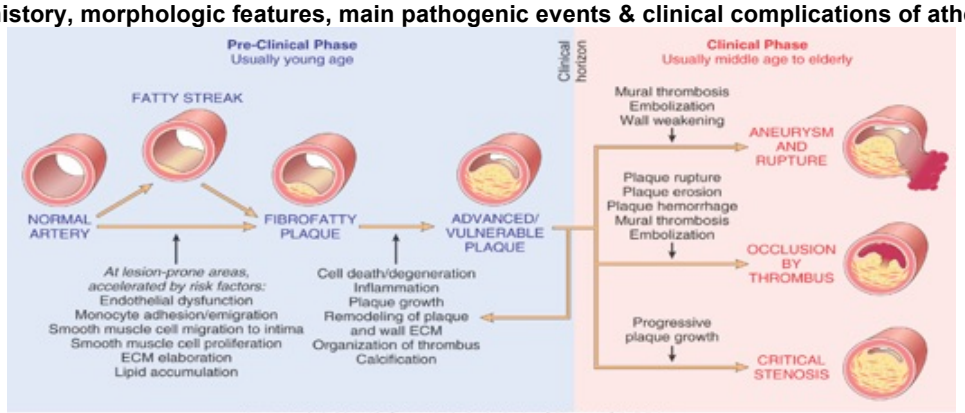
ATHEROSCLEROTIC PLAQUE RUPTURE.
(A) *Plaque rupture* without superimposed thrombus, in a patient who died suddenly. (B) Acute coronary thrombosis superimposed on an atherosclerotic plaque with focal disruption of the fibrous cap, triggering fatal MI. In both (A) and (B), an arrow points to the site of plaque rupture.

- **"VULNERABLE" PLAQUES** *(AKA vulnerable to **acute plaque changes**: rupture/erosion/hemorrhage into plaque)*
  - ***Fibrous cap***: thinner, few SMCs; more inflammatory cells; ***lipid core is larger***
  - Often do not cause clinically significant stenosis
  - It is difficult to predict which plaques are *vulnerable to acute plaque change*, but extrinsic influences such as **ADRENERGIC STIMULATION** contribute to acute plaque change
    - ↑ Blood pressure
    - Causes vasoconstriction
    - Puts physical stress on vulnerable plaques
- **THROMBOSIS:** forms on disrupted plaque; causes partial or complete occlusion; may embolize; may dissolve or be resorbed increasing plaque size
- **VASOCONSTRICTION:** stimulated by circulating or local factors; may make a partial occlusion complete



VULNERABLE vs STABLE PLAQUE – Whereas stable plaques have densely collagenous and thickened fibrous caps with minimal inflammation and negligible underlying atheromatous core, vulnerable plaques (prone to rupture) are characterized by thin fibrous caps, large lipid cores, and increased inflammation.

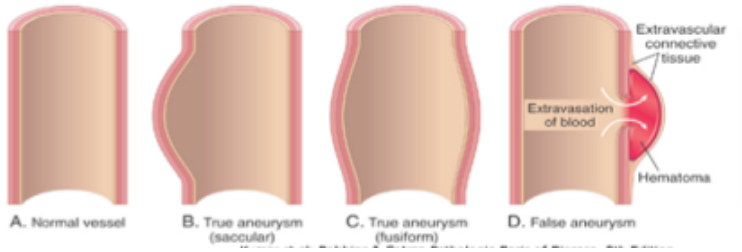
The natural history, morphologic features, main pathogenic events & clinical complications of atherosclerosis:



ANEURYSMS & DISSECTION

ANEURYSMS

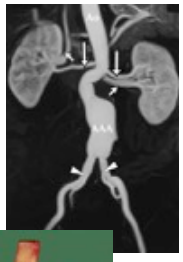
- An abnormal dilation of a blood vessel or heart chamber wall
- Most common in the aorta & heart
- **TRUE ANEURYSM**: arterial or ventricular wall is thinned but intact; blood remains within the confines of the circulatory system
  - ****Abdominal Aortic Aneurysm:** ATHEROSCLEROSIS (intimal thickening), MALES, SMOKERS
  - ****Thoracic Aortic Aneurysm:** HYPERTENSION causes CYSTIC MEDIAL DEGENERATION (from ischemia to vessel wall from due to narrowing of vaso vasorum)
- **FALSE ANEURYSM (PSEUDOANEURYSM)**: an extravascular hematoma due to defect in vascular wall; communicates with intravascular space; thus, creates a *pulsating hematoma*

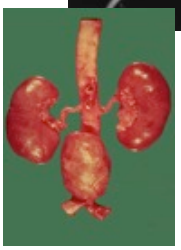


- Classification by size & shape
  - SACCULAR (spherical, "berry"): 5-20 cm in diameter
  - FUSIFORM (circumferential dilation of a long segment): < 20 cm in diameter

PATHOGENESIS OF TRUE ANEURYSMS

- ***ATHEROSCLEROSIS** is the most frequent cause of aneurysms (abdominal aortic aneurysm). Atherosclerotic plaque compresses media, compromises nutrient & waste diffusion, results in media degeneration & necrosis; MMP from inflammation degrades ECM.*
- HYPERTENSION (*ascending aortic/thoracic aortic aneurysms*)
- Weak connective tissue in vascular wall
  - Marfan Syndrome – defective fibrillin
  - Loeys-Dietz Syndrome – defective elastin, collagens I & III
  - Ehlers-Danles Syndrome – defective type III collagen
  - Vitamin C deficiency – altered collagen cross-linking
- Inflammation: changes balance of collagen degradation & synthesis
  - Matrix metalloproteinases (MMP) production by macrophages – degrades all components of ECM (collagens, elastin, proteoglycans, etc.)
  - Sources: atherosclerosis, vasculitis
- **Cystic Medial Degeneration (CMD)** from ischemia of vessel wall
  - Of inner media due to thickening of wall – *i.e. from atherosclerosis*
  - Of outer media due to narrowing of vaso vasorum – *i.e. damage from HTN (thoracic aortic aneurysm)*
  - **Results in:** loss of SMCs, scarring & loss of elasticity, inadequate ECM synthesis
- Other causes: congenital defects (i.e. fibromuscular dysplasia), infections (mucotic aneurysm), trauma, systemic diseases, vasculities



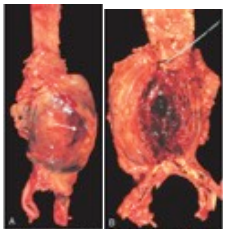


****ABDOMINAL AORTIC ANEURYSM** *"Intimal proliferation with fibrous cap formation"*

- Abdominal aorta is the most frequent site of **ATHEROSCLEROTIC** aneurysms
- Onset rarely before the age of 50; more common in men & smokers
- **LOCATION**: usually below the renal arteries & above the bifurcation
- Saccular or fusiform, <15 cm in diameter & <25 cm in length
- *Intima shows severe complicated atherosclerosis with destruction of underlying aortic media*
- **MURAL THROMBUS is common** *(large thrombus on luminal surface that adheres to wall of blood vessel)*
- Origins of the renal, superior, & inferior mesenteric arteries may be involved by exerting direct pressure on these branches OR by narrowing/occlusion of the ostia by mural thrombi
- Often, atheromatous ulcers occur

ABDOMINAL AORTIC ANEURYSM: CLINICAL COURSE

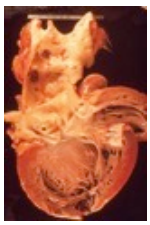
- RUPTURE may cause massive, often fatal, hemorrhage
  - **Risk directly related to DIAMETER!**
    - <4 cm – no risk of rupture
    - 4-5 cm – 1% risk of rupture/year
    - 5-6 cm – 11%
    - **>6 cm – 25%**
  - Use prosthetic grafts to surgically replace defect before rupture
- OBSTRUCTION of a branch vessel causing downstream ischemia (*i.e. SMA/IMA or renal arteries)*
- EMBOLISM from atheroma or *mural thrombosis*
- **CLINICAL PRESENTATION**: abdominal mass (often **palpably pulsating**), **bruits** on auscultation
- **TREATMENT**: for aneurysms > 5cm, surgery or endoluminal stenting for some patients



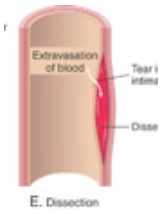
ABDOMINAL AORTIC ANEURYSM
LEFT: gross, external view of large aortic aneurysm that ruptured; the rupture site in indicated by the arrow
RIGHT: opened view with the location of the rupture indicated by a probe. The wall of the aneurysm is exceedingly thin, & the lumen is filled by a large quantity of layered but largely unorganized thrombus

****THORACIC AORTIC ANEURYSM** *(ascending aorta)*

- **HYPERTENSION** is the most common cause
- **SYPHILITIC (LUETIC) ANEURYSM**: less common with early & effective treatment of syphilis
  - ***Tree-bark appearance*** *from scarring & fibrosis*
  - Inflammation in **adventitia** of **thoracic aorta** damages the *vaso vasorum* causing the lumina to narrow → ischemic injury to aortic media, loss of elastic fibers & SMCs, & scarring (CMD)
    - Progression causes obliterative endarteritis of small vessels, seen in tertiary syphilis
  - Aorta loses elasticity & may dilate
  - **Wrinkled intima** (from contraction of scar tissue) is more susceptible to development of **atherosclerosis** *(ascending aorta is not normally prone to atherosclerosis, but it is if wrinkling of the intima occurs)*
  - **Leutic aortitis** may also cause annular dilation of aortic valve, valvular insufficiency, & left ventricular volume-overload hypertrophy
- **CLINICAL SIGNS & SYMPTOMS:** Due to encroachment on various structures
  - Mediastinal structures; lung & airways – breathing difficulties; esophagus – swallowing problems; ribs & vertebral bodies – pain due to bone erosion; cardiac disease – aortic valvular incompetence; RUPTURE!



AORTIC DISSECTION: ***INTIMAL tear with dissection of blood through the media of aortic wall →DOUBLE LUMEN***



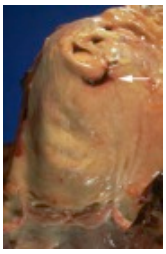
- Catastrophic illness: *Formation of a blood filled channel within the aortic wall (between intima & media) that often RUPTURES causing a* ***MASSIVE HEMORRHAGE***
- May or may not be associated with aortic dilation
- Two groups of patients:
  - **HYPERTENSIVE MEN** 40-60 YEARS OLD >90% OF CASES
  - Younger patients with systemic or localized **abnormality of connective tissue** (i.e. **Marfan syndrome**)
  - *Can also occur in pregnancy, postpartum – cause not known*
- May be a complication of arterial cannulation, such as coronary catheterizations
- **UNUSUAL** in substantial atherosclerosis or other causes of medial scarring because the plaques prevent the dissection from propagating

AORTIC DISSECTION: PATHOGENESIS

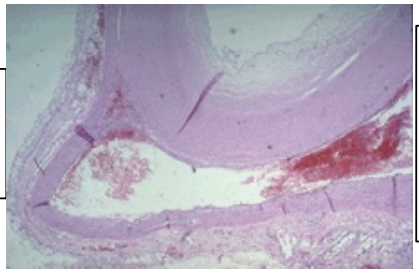
- **HYPERTENSION**: THE MAJOR RISK FACTOR & most common cause
  - Medial hypertrophy of vaso vasorum with subsequent changes: loss of media SMCs & elastic fibers, disorganized ECM
- **ACQUIRED CONNECTIVE TISSUE DISORDERS** (i.e. **Marfan Syndrome**, Ehlers-Danlos Syndrome)
  - Trigger for intimal tear – *unknown*

AORTIC DISSECTION: MORPHOLOGY

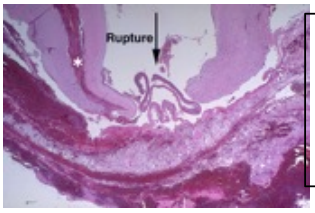
- **Usually** (not always) **an INTIMAL TEAR of the ascending aorta** (usually within 10 cm of aortic valve)
  - Transverse or oblique (has sharp jagged edges)
  - May extend proximally to the heart or distally
- Extends between the middle & outer third of the media
- **CAUSE OF DEATH: aorta ruptures causing massive hemorrhage into pericardial cavity (CARDIAC TAMPONADE)** or pleural cavity (HEMOTHORAX) or peritoneal cavity
- OR it may create a new vascular channel with second or distal tear (FALSE CHANNEL)
- **Often no specific underlying pathology detected**
- **CYSTIC MEDIAL DEGENERATION (CMD) is the most frequently detectable lesion**
  - *Causes loss of SMCs & elasticity of the media, scarring, & inadequate ECM synthesis*



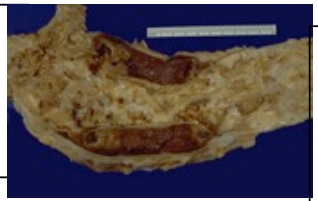
AORTIC DISSECTION – There is a tear 7 cm above the aortic valve & proximal to the great vessels in this aorta.



AORTIC DISSECTION – Here, the dissection went into the muscular wall. In any case, an aortic dissection is an EXTREME EMERGENCY & can lead to death in a matter of minutes. Blood dissecting up around the great vessels can close off the carotids. Blood can dissect down to the coronaries & shut them off.



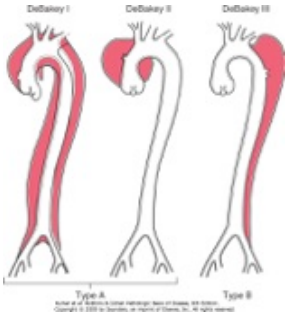
AORTIC DISSECTION – The tear (arrow) in this aorta extends through the media, but blood also dissects along the media (asterick).



AORTIC DISSECTION – This aorta has been opened longitudinally. The red-brown thrombus can be seen on both sides of the section as it extends around the aorta. The intimal tear would have been at the left. This creates a "DOUBLE LUMEN" to the aorta – aka "DOUBLE BARREL AORTA"

AORTIC DISSECTION – CLASSIFICATION

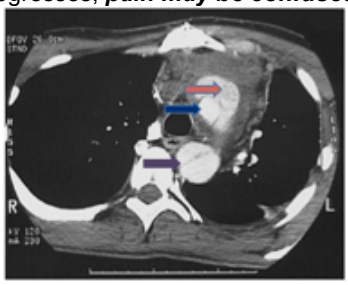
- **TYPE A**: proximal lesions; ascending aorta or ascending & descending aorta – *more common, more dangerous*
- **TYPE B**: distal lesions; does NOT involve ascending aorta; begins DISTAL to subclavian artery



CLASSIFICATION OF DISSECTIONS – TYPE A (proximal) involves the ascending aorta, either as part of a more extensive dissection (DeBakey I) or in isolation (DeBakey II). TYPE B (distal or DeBakey III) dissections arise beyond the takeoff of the great vessels. The serious complications predominantly occur in TYPE A dissections.

**AORTIC DISSECTION – SIGNS & SYMPTOMS

- **SUDDEN onset** of excruciating PAIN, usually beginning in anterior chest, radiating to **BACK**, & moves downward as dissection progresses; ***pain may be confused with acute MI***



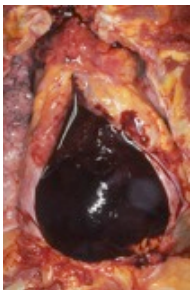
CHEST CT: AORTIC DISSECTION – Demonstrates dissection in both the proximal ascending (blue) & the descending (purple) aorta. There is a hematoma (red) formation adjacent to the aorta.

AORTIC DISSECTION – COMPLICATIONS

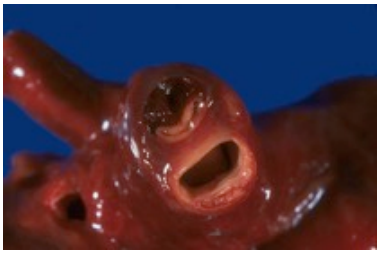
- Dissection of great vessels of the neck or coronary, renal, mesenteric, or iliac arteries
- **RETROGRADE** dissection may disrupt the AORTIC VALVE
- **RESULTS**: CARDIAC TAMPONADE, AORTIC INSUFFICIENCY, & MI

AORTIC DISSECTION – COURSE

- Used to be invariable fatal, but now with plication of aorta & early intensive hypertensive agents – 65-75% survival
- Most TYPE B dissects can be managed conservatively



AORTIC DISSECTION – An aortic dissection may lead to HEMOPERICARDIUM when blood dissects through the media proximally. Such a massive amount of hemorrhage can lead to CARDIAC TAMPONADE.



AORTIC DISSECTION – The right common carotid artery is compressed by blood dissecting upward from a tear with aortic dissection. Blood may also dissect to coronary arteries. Thus, patients with aortic dissection may have symptoms of **severe chest pain (DISTAL DISSECTION)** or may present with findings that suggest a **stroke (CAROTID DISSECTION)** or **myocardial ischemia (CORONARY DISSECTION)**