Blood Pressure and Hypertension

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Blood Pressure and Hypertension - Objectives

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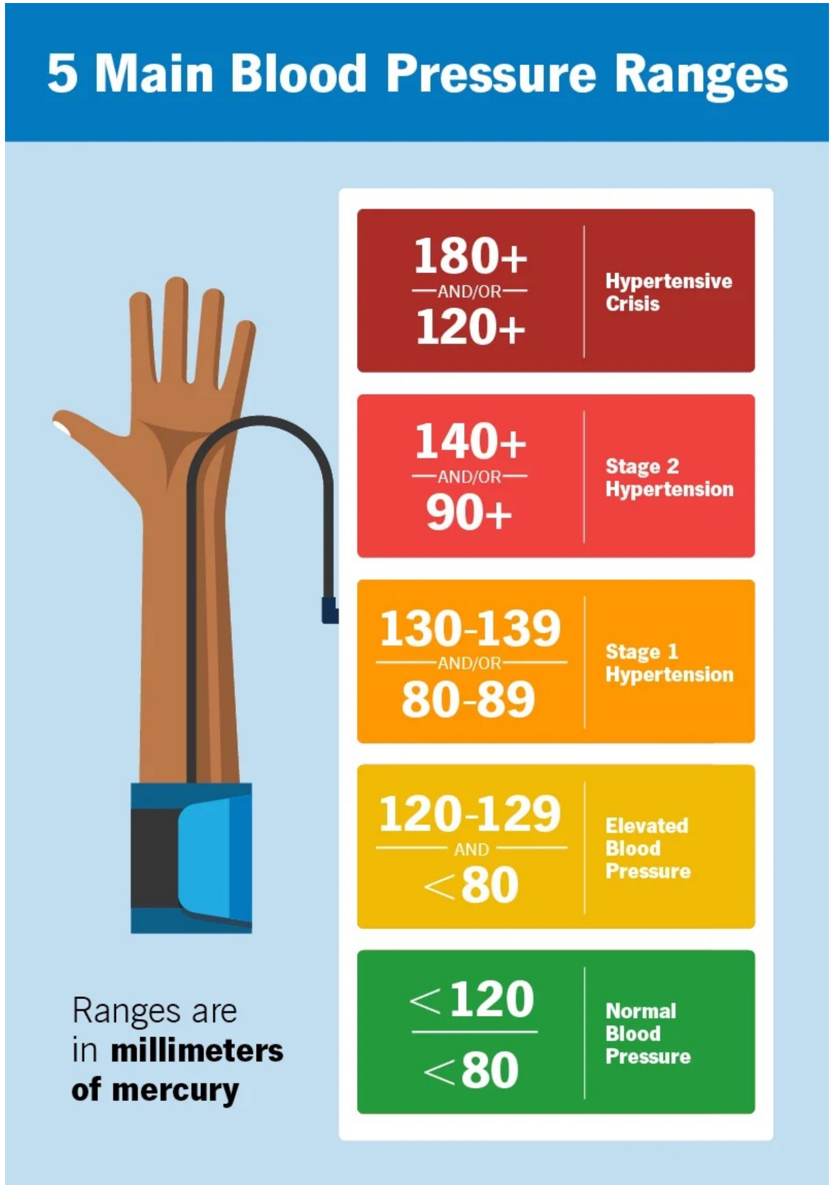
1. Know what is normal and high blood pressure, and why maintaining normal blood pressure is important.
2. Understand the circulatory system and differentiate between systemic and pulmonary hypertension.
3. Know what part of the circulatory system is primarily responsible for regulating blood pressure via modulating systemic vascular resistance.
4. Know other factors that combined regulate blood pressure, especially the autonomic nervous system and the renin-angiotensin system.
5. Know the risk factors for, and epidemiology of, hypertension.
6. Understand the difference between primary and secondary hypertension.
7. Understand the complications of hypertension and the pathologic changes of the circulatory tissues that cause them.

Blood Pressure Regulation is Critical



- Too low, and the organs are not perfused with blood. We may become dizzy and then have syncope (passing out), kidney failure, cyanotic (blue) extremities, and eventually, shock and cell death.
- Too high, and there is an increased risk for heart attack, stroke, and kidney failure, due to alterations of the vessel walls.
- Maintenance of normal BP is an intricate balance of neural, hormonal, and physical pathways.

The Heart and Blood Vasculature

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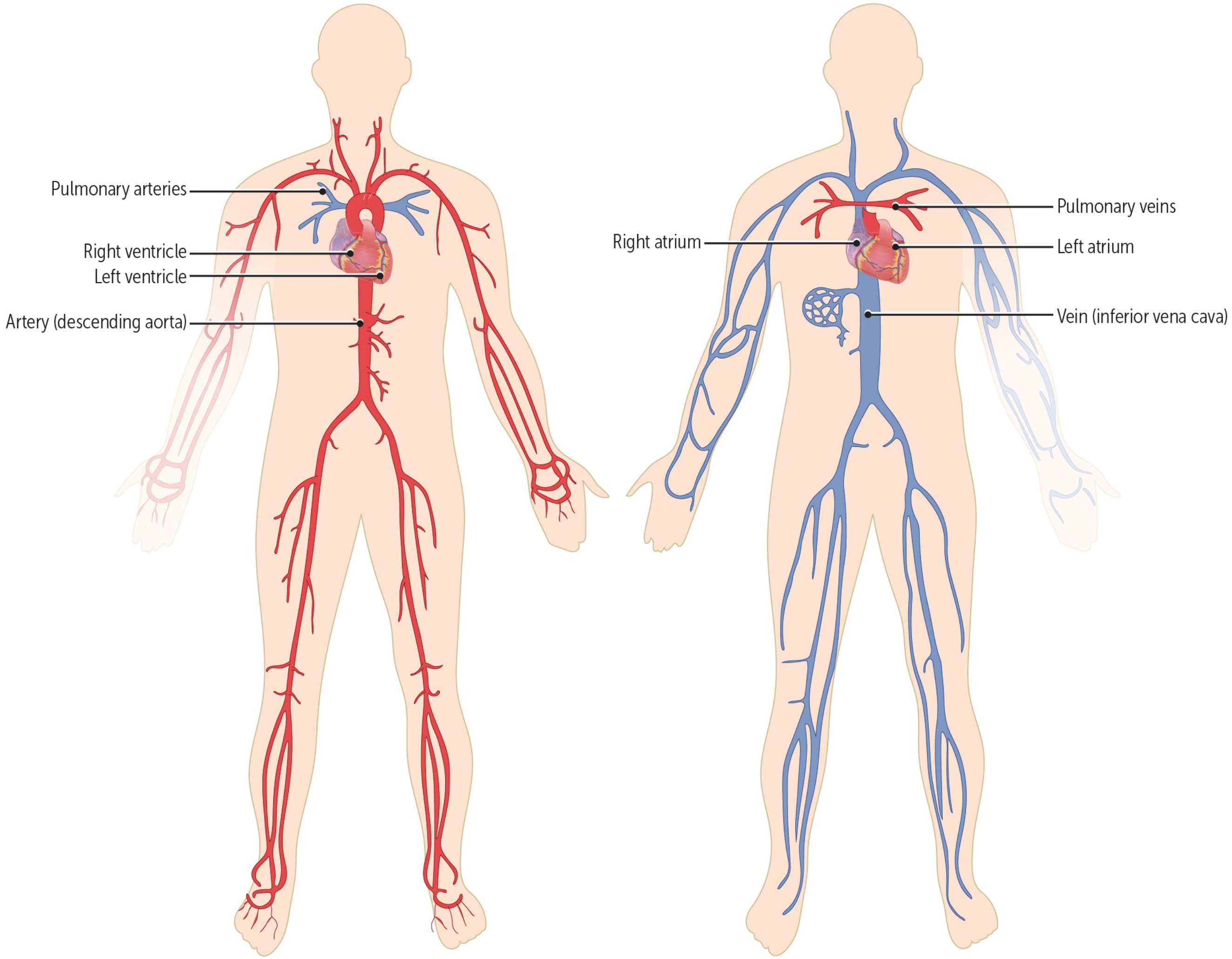

Two Distinct Circulatory Systems

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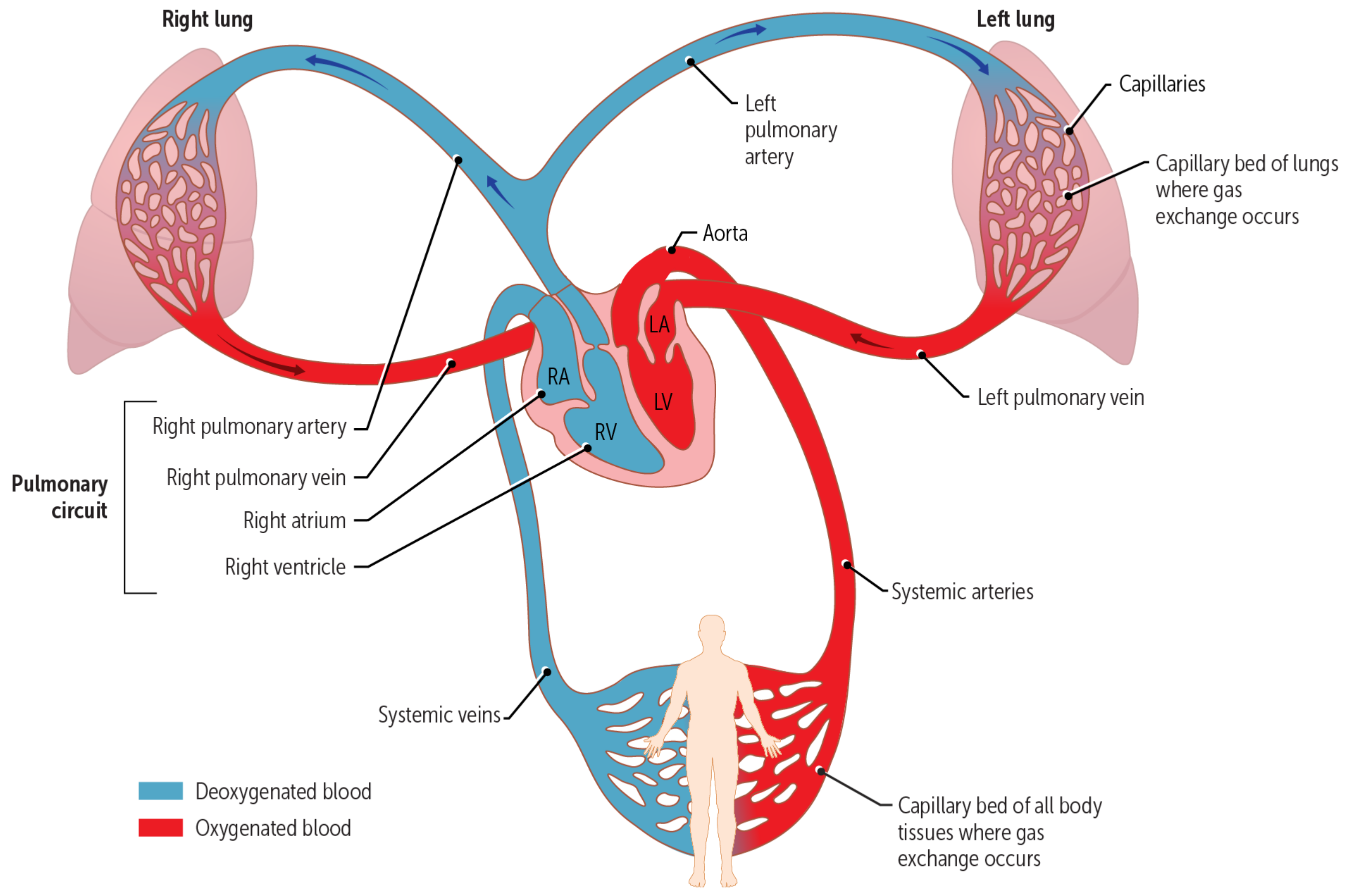
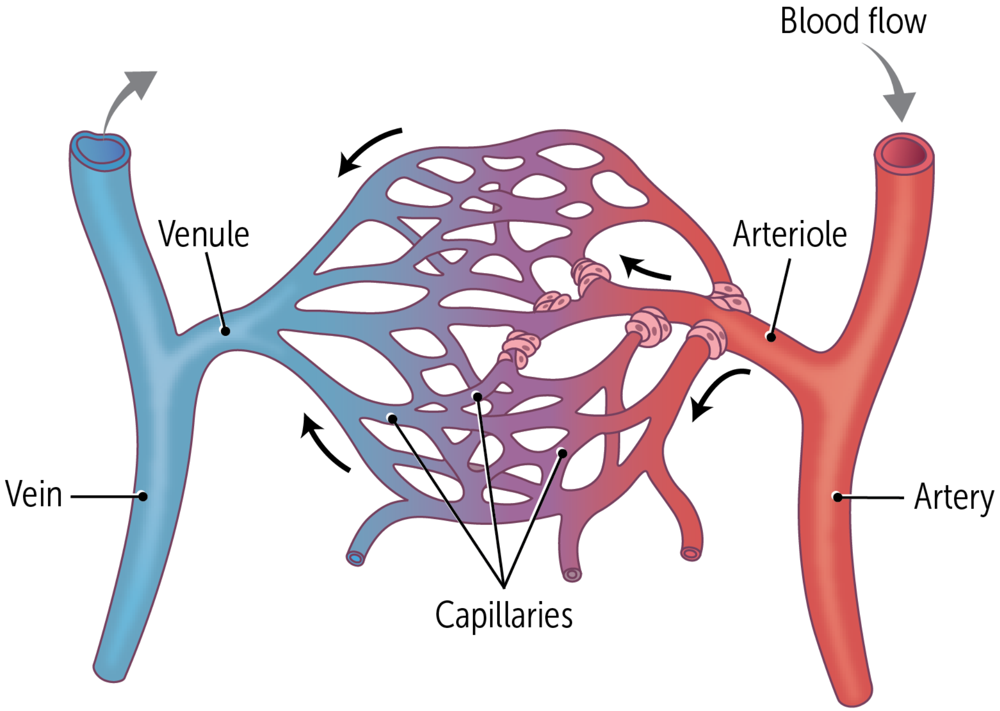
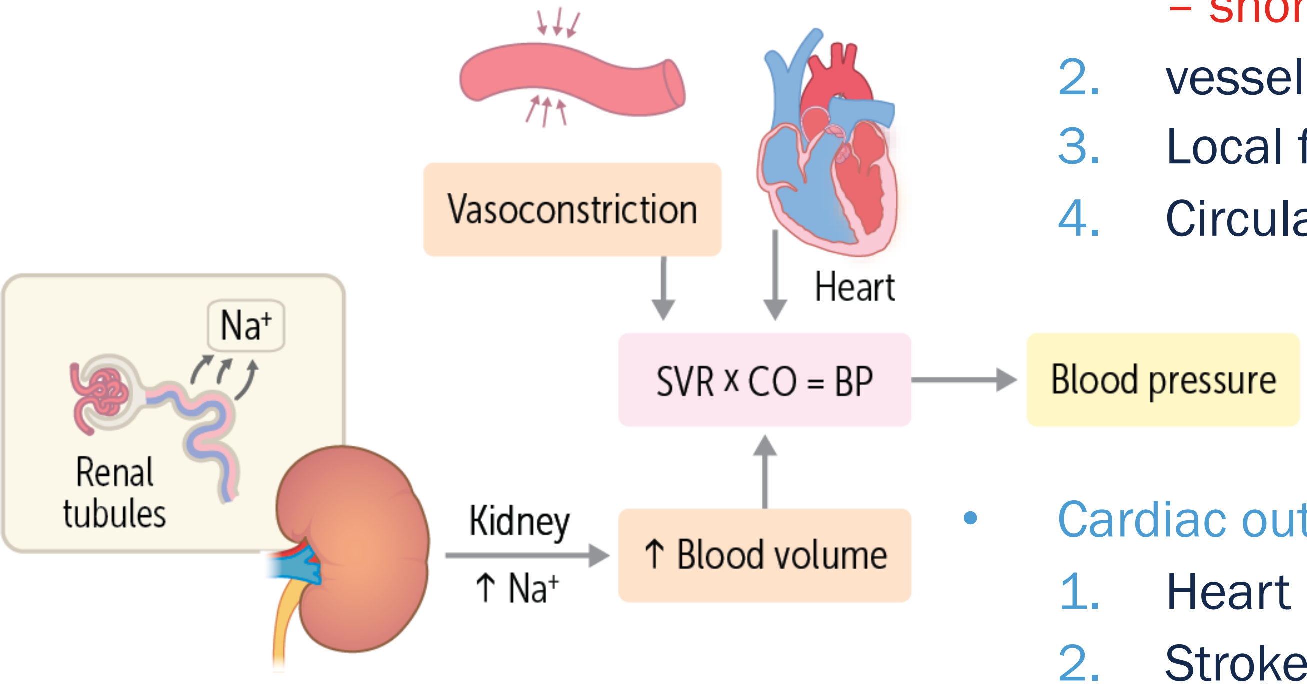


Arterioles Control Peripheral Vascular Resistance



- Arteries – primarily conduits
- Arterioles
  1. adjust blood distribution among tissues
  2. act as "resistance" vessels to regulate blood pressure
- Capillaries – oxygen/CO_2 and metabolite exchange
- Veins – conduits and reservoir

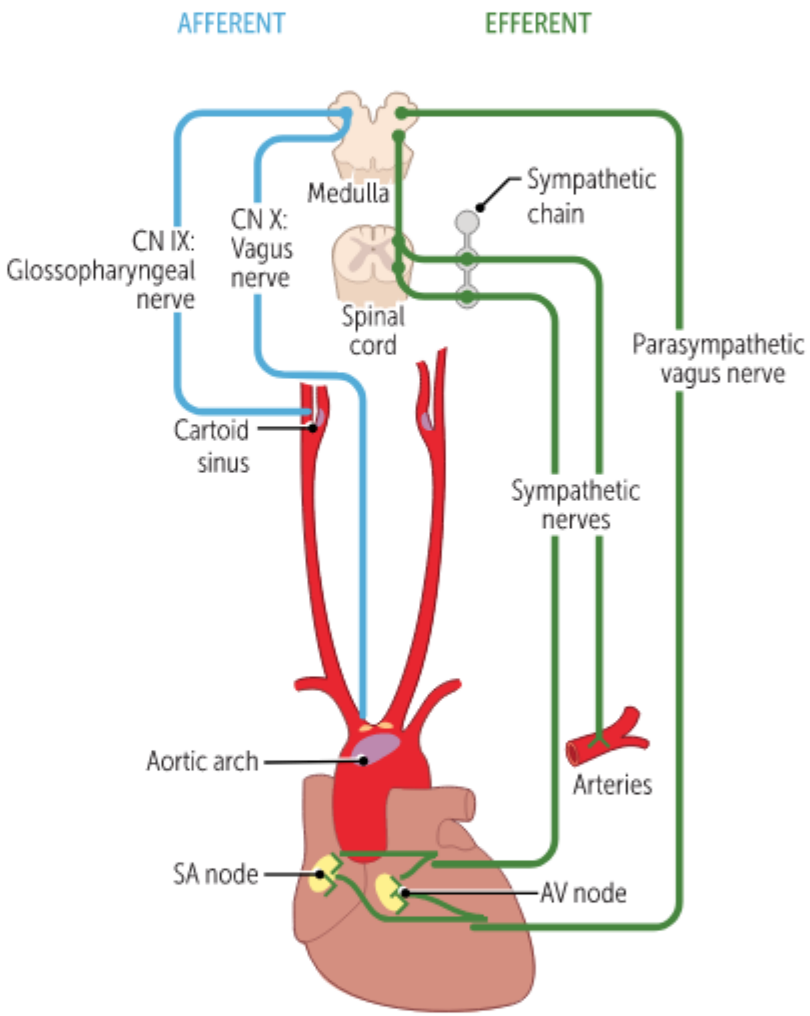
Regulators of Blood Pressure



- Systemic vascular resistance
  1. Autonomic (sympathetic/parasympathetic) nervous system – short term BP control
  2. vessel compliance (stretch)
  3. Local factors (nitric oxide, O_2, CO_2)
  4. Circulating molecules (vasopressin, endothelin)

- Cardiac output
  1. Heart rate
  2. Stroke volume
     i. Preload – vol of blood to the heart (renin-angiotensin-aldosterone system) – long term BP control
     ii. Afterload – pressure the heart beats against
     iii. Contractility – strength of heart contraction

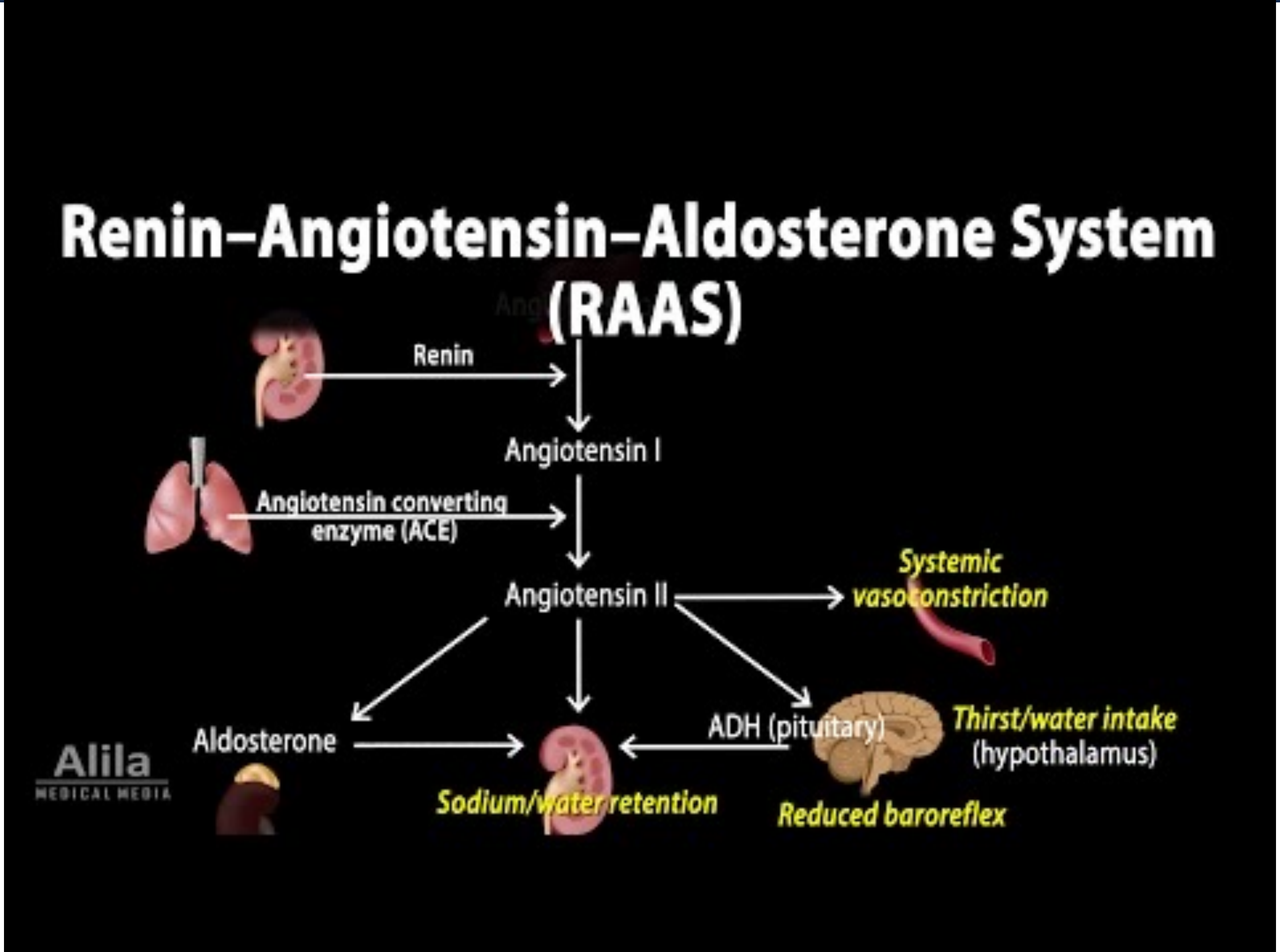
Baroreceptors - modulate the autonomic control of BP (short term)



- Baroreceptors – efferent signals to the CNS
  1. Aortic arch
  2. Carotid sinus

- Autonomic nerves – afferent signals back out to the:
  1. Arterioles – causes constriction
  2. SA and AV node of heart to modulate heart rate

Renin Angiotensis Aldosterone System Control of BP (long term)



Humoral Regulation of Blood Pressure

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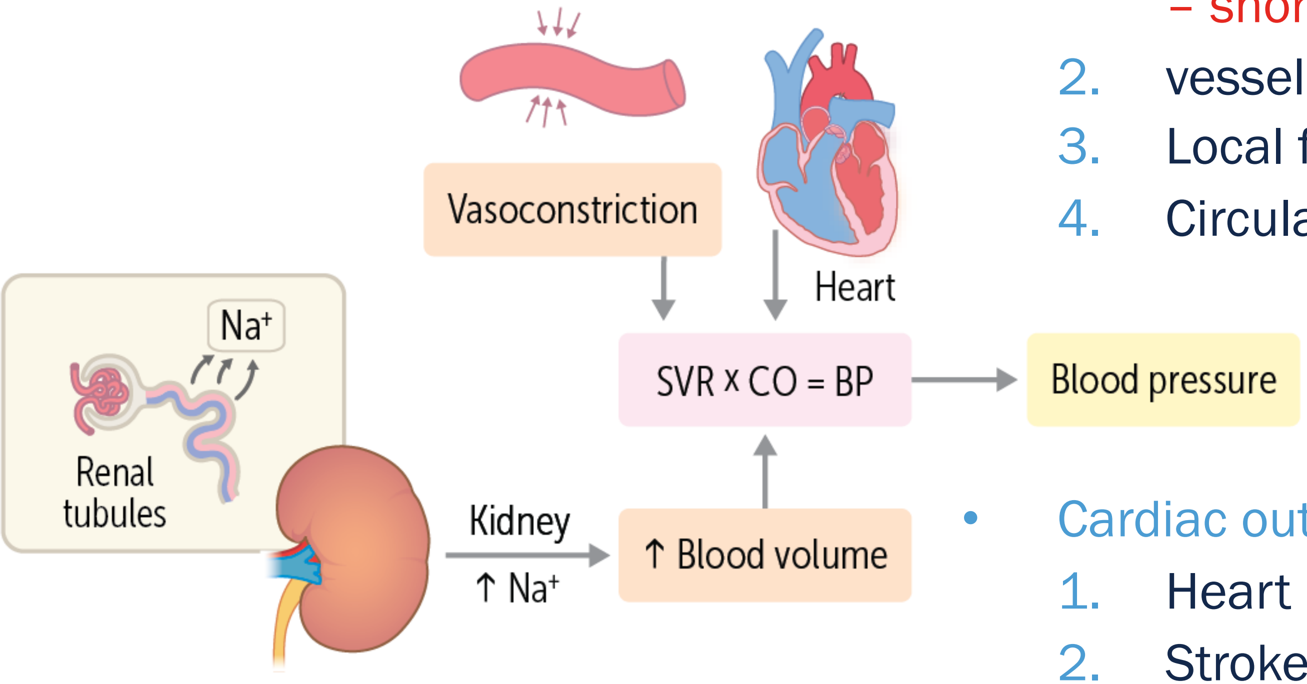
Substance	Function	Released from	Target(s)	Upregulated by:
Histamine	Vasodilator Mediator of allergic response	Mast cells	Smooth muscle (H1 and H2 receptors)	Allergens
Atrial natriuretic peptide (ANP)	Vasodilator Urinary sodium excretion	Atrial cardiomyocytes	Kidneys Vascular smooth muscle	Atrial stretch
Brain natriuretic peptide (BNP)	Vasodilator Urinary sodium excretion	Ventricular cardiomyocytes	Kidneys Vascular smooth muscle	Ventricular stretch
Bradykinin	Vasodilator, inflammatory mediator	Cleaved from kininogen (from liver)	Vascular smooth muscle	Inflammation
Nitric oxide	Vasodilator	Vascular endothelium	Vascular smooth muscle	Inflammation, shearing force of blood flow
Endothelin	Vasoconstrictor	Vascular endothelium	Vascular smooth muscle	Angiotensin II, ADH, shearing force of blood flow
Vasopressin (ADH)	Vasoconstrictor Renal water reabsorption	Posterior pituitary	Vascular smooth muscle Renal tubular cells	Low blood volume, high serum osmolality

Regulators of Blood Pressure



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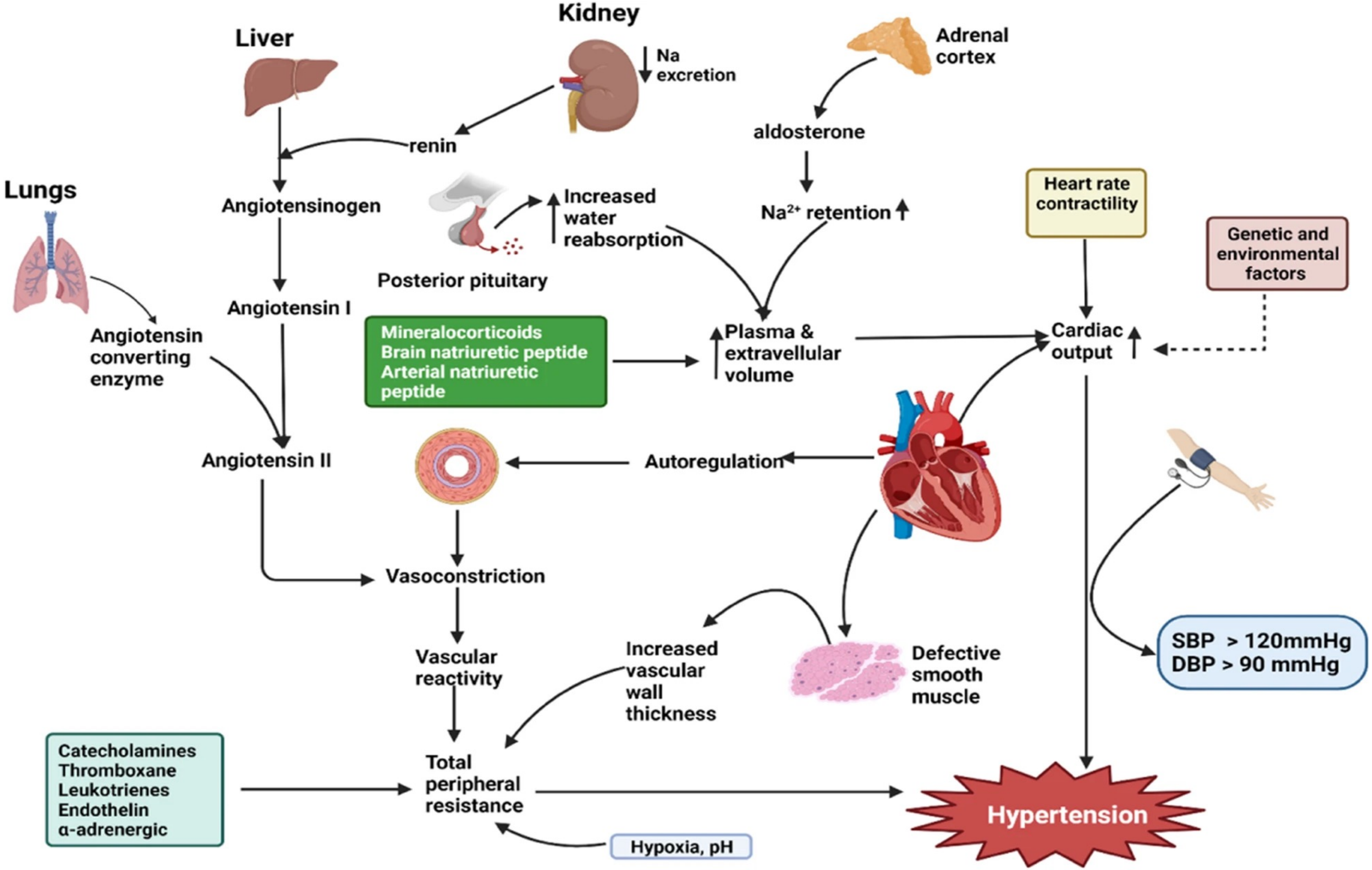
BP Regulation – the big picture

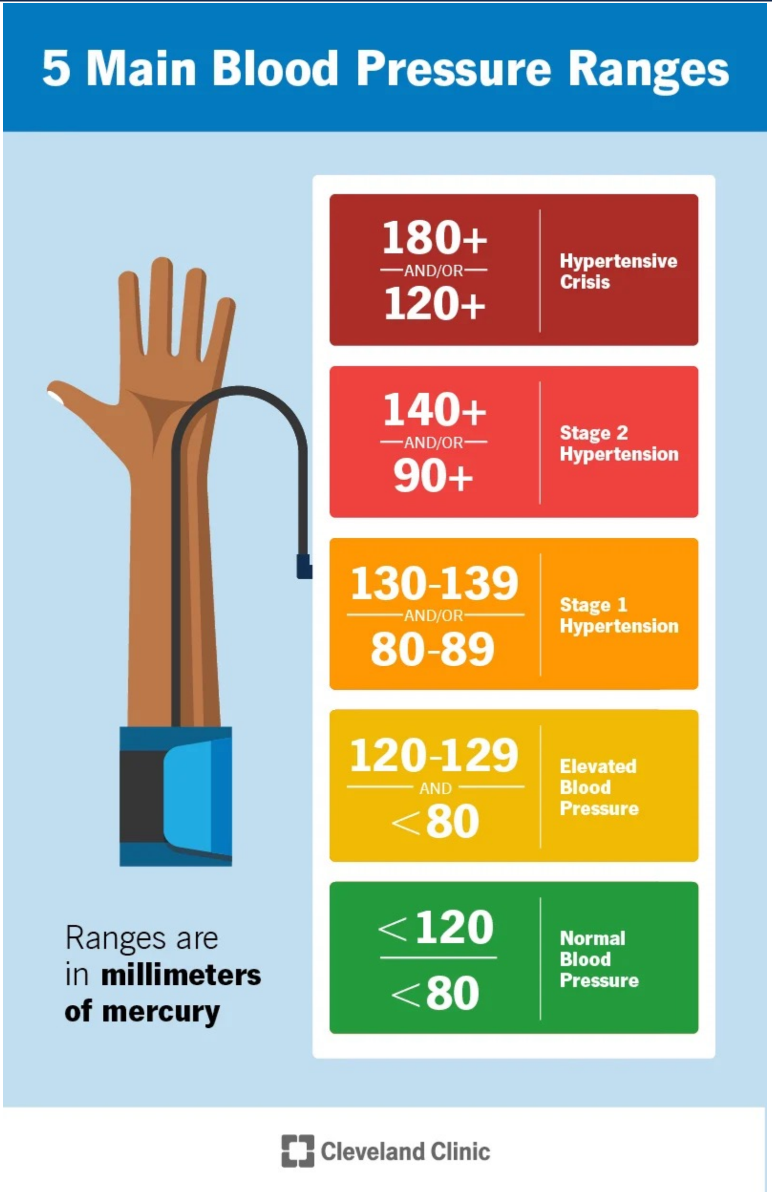


Hypertension - epidemiology

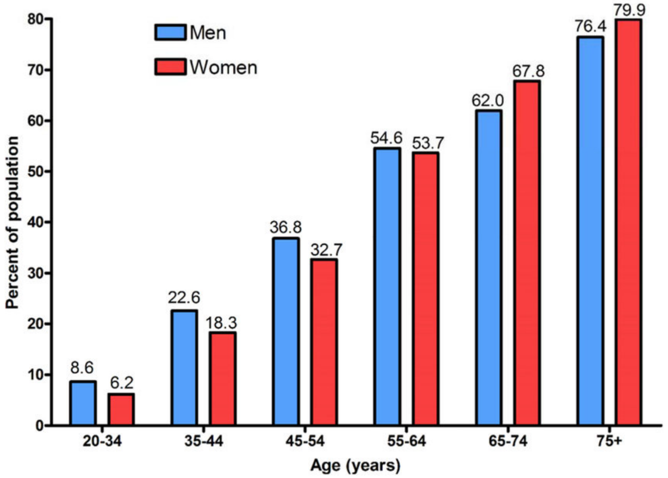
Hypertension Epidemiology

- Prevalence of Hypertension worldwide:
  - ***1 Billion***
- Deaths worldwide:
  - ***7 million per year***
- In USA, **90% lifetime risk** of Hypertension is normal at age 55.
- Suboptimal blood pressure is the **number one** attributable cause of death in the world.
- Hypertension is the **most** common cause of preventable death in developed countries.
- Hypertension is the **number one** cause of congestive heart failure and stroke, plus the ***second*** leading cause of renal failure.

Hypertension – risk factors



- Age
- Genetics (family history)
- Tobacco use
- Increased body mass (BMI; obesity)
- Sedentary lifestyle
- Stress
- Chronic conditions such as diabetes
- Chronic kidney disease (CKD)
- Obstructive sleep apnea (OSA)
- Others



Hypertension – types

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TYPES OF HYPERTENSION

90-95% of cases → **PRIMARY**

- also called "essential hypertension"
- most cases the causes of this type is **not known**
- majority of people with this type feel no different from those who have normal blood pressure.

5-10% of cases → **SECONDARY**

- this is when high blood pressure is as a **result of other medical problems (like kidney or liver problem) or medication**

Secondary Hypertension – causes

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Table 4. Most Common Causes of Secondary Hypertension by Age*

Age groups	*Percentage of patients who have hypertension with an underlying cause*	*Most common etiologies†*
Children (birth to 11 years)	70 to 85	Renal parenchymal disease Coarctation of the aorta
Adolescents (12 to 18 years)	10 to 15	Renal parenchymal disease Coarctation of the aorta
Young adults (19 to 39 years)	5	Thyroid dysfunction Fibromuscular dysplasia Renal parenchymal disease
Middle-aged adults (40 to 64 years)	8 to 12	Hyperaldosteronism Thyroid dysfunction Obstructive sleep apnea Cushing syndrome Pheochromocytoma
Older adults (65 years and older)	17	Atherosclerotic renal artery stenosis Renal failure Hypothyroidism

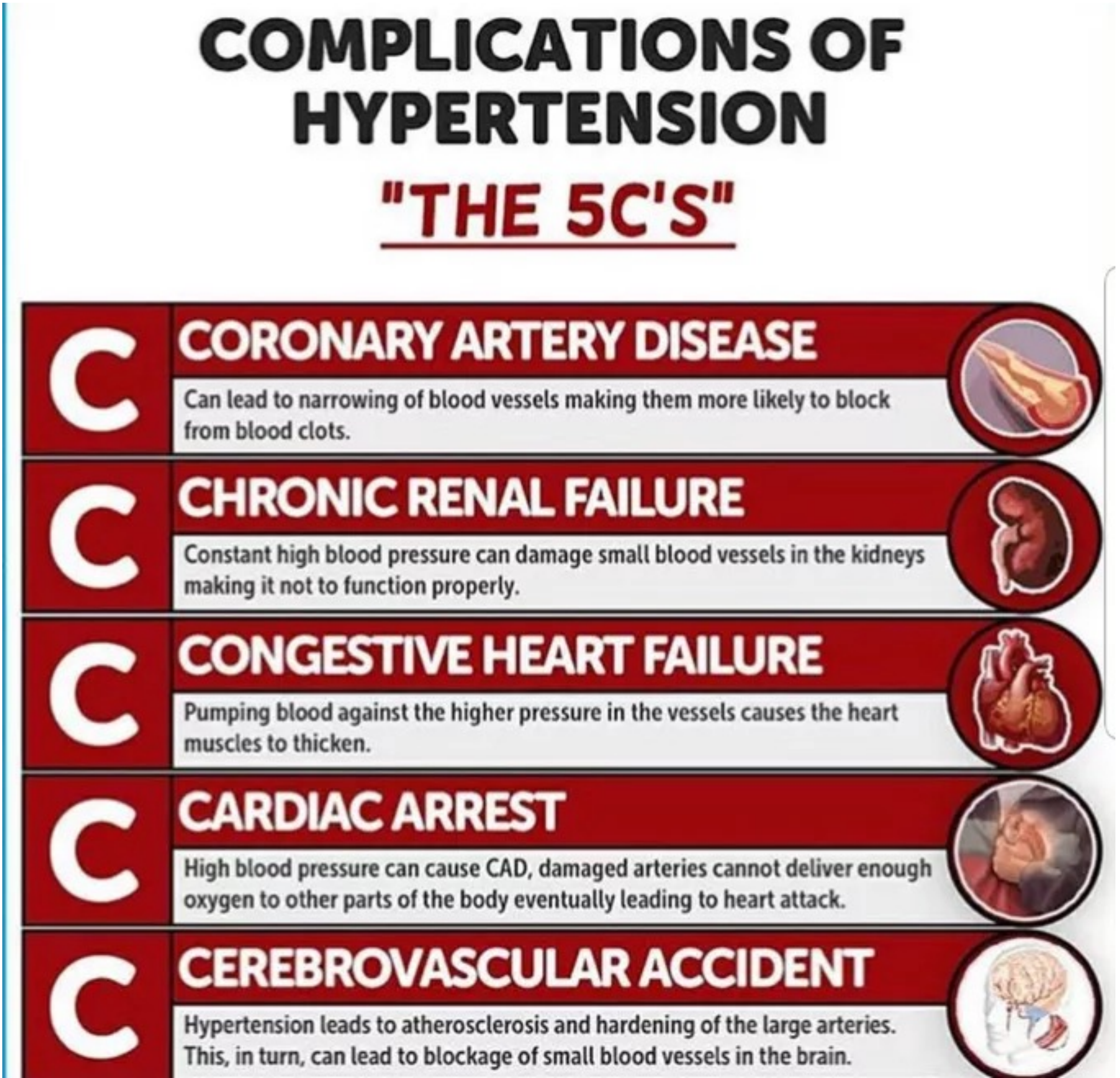
- Vascular abnormalities affecting perfusion of the kidneys
- Endocrine abnormalities affecting the RAAS or vascular tone
- Intrinsic kidney disease/reduced GFR
- May be definitively treatable, unlike essential HTN

Hypertension – patient presentation

- Asymptomatic - may delay the diagnosis and treatment, as patients do not have a reason to seek medical attention. The high blood pressure is usually picked up incidentally at a routine well visit or at a health fair or employment physical. HTN is known as the SILENT KILLER

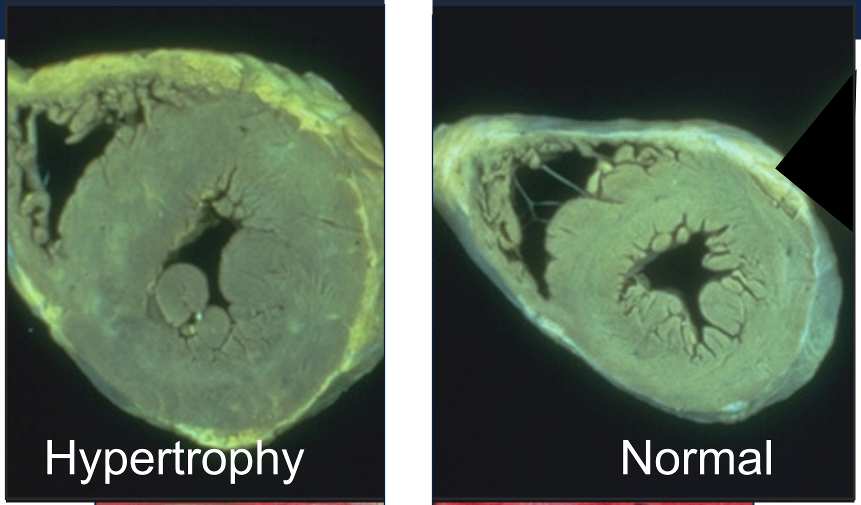
- Hypertensive Emergency – very high blood pressure, and the patient is experiencing end-organ (kidney, brain, heart) damage, symptoms can include:
  - Severe chest pain
  - Altered mental status
  - Blurred vision
  - Shortness of breath
  - Decrease in the urine output
  - Headache

Hypertension – complications



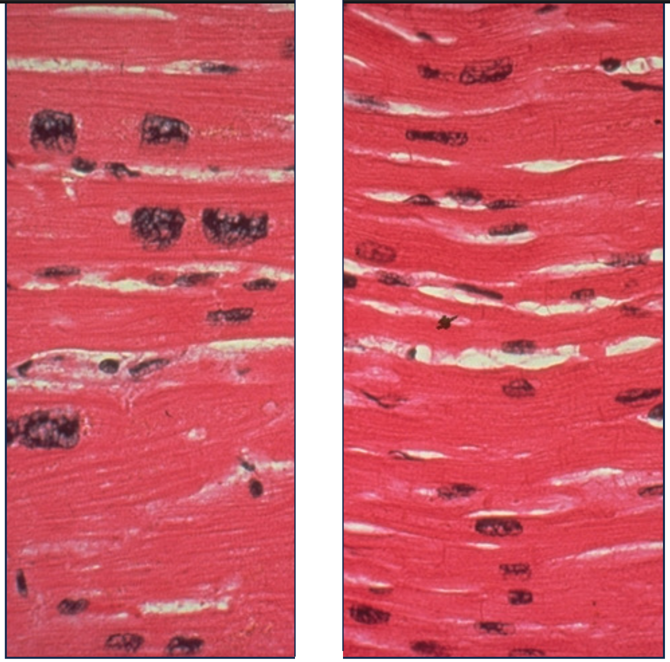
- Damage to the large arteries – <u>increased atherosclerosis</u>
  1. coronary artery disease (heart attack)
  2. cerebrovascular accident (stroke)
  3. peripheral vascular disease (aneurysms, dissections, erectile dysfunction)
- Damage to the heart
  1. myocardial hypertrophy and heart failure
  2. sudden cardiac arrest
- Organ failure due to small artery and arteriole injury
  1. chronic kidney failure

Pathology: HTN Effects on Heart



Enlarged cardiac myocytes:

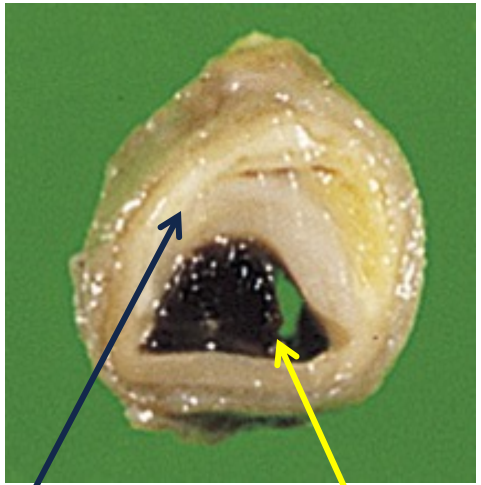
Increased cytoplasm,
Larger nuclei



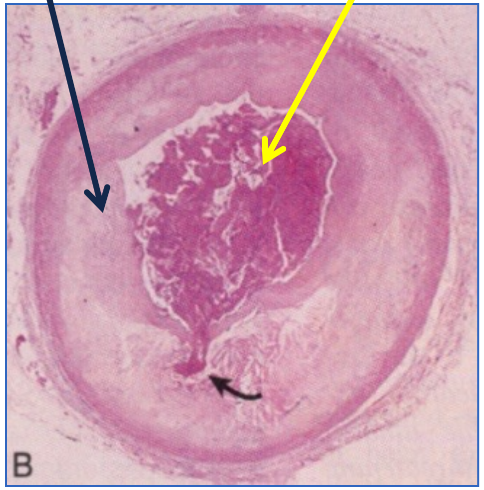
Normal cardiac myocytes

Same high power magnification

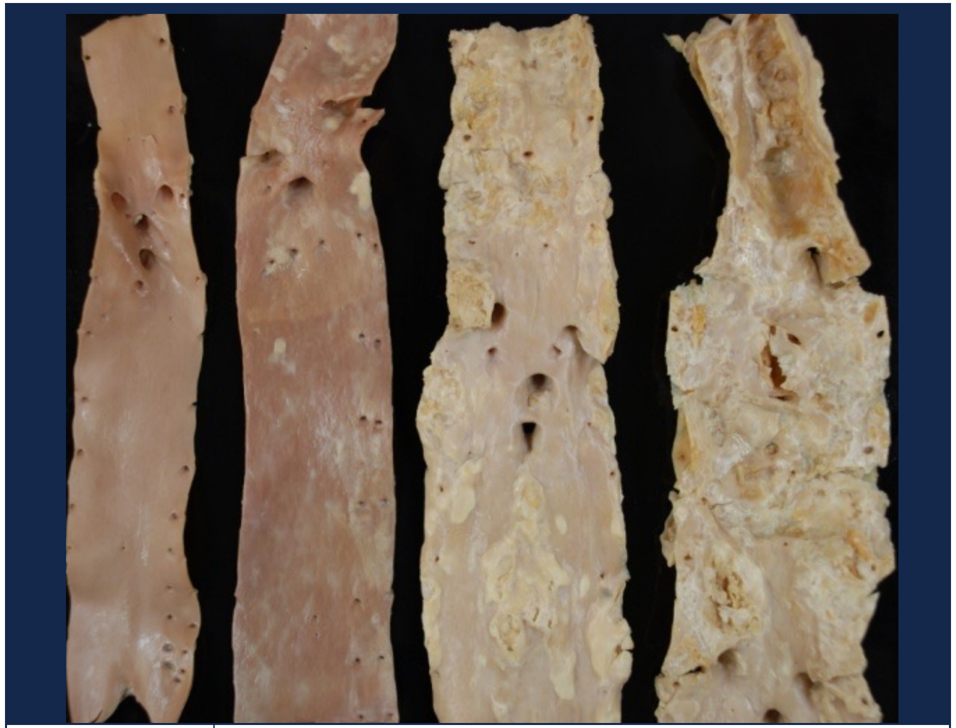
Pathology: HTN Effects on Large-Medium Arteries



Atherosclerosis Thrombus

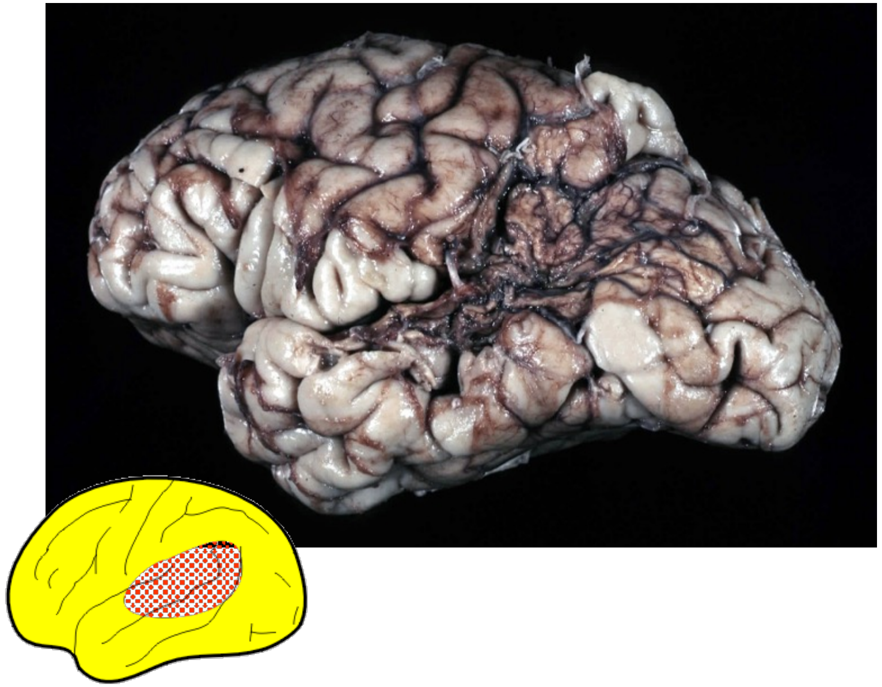


Aortas

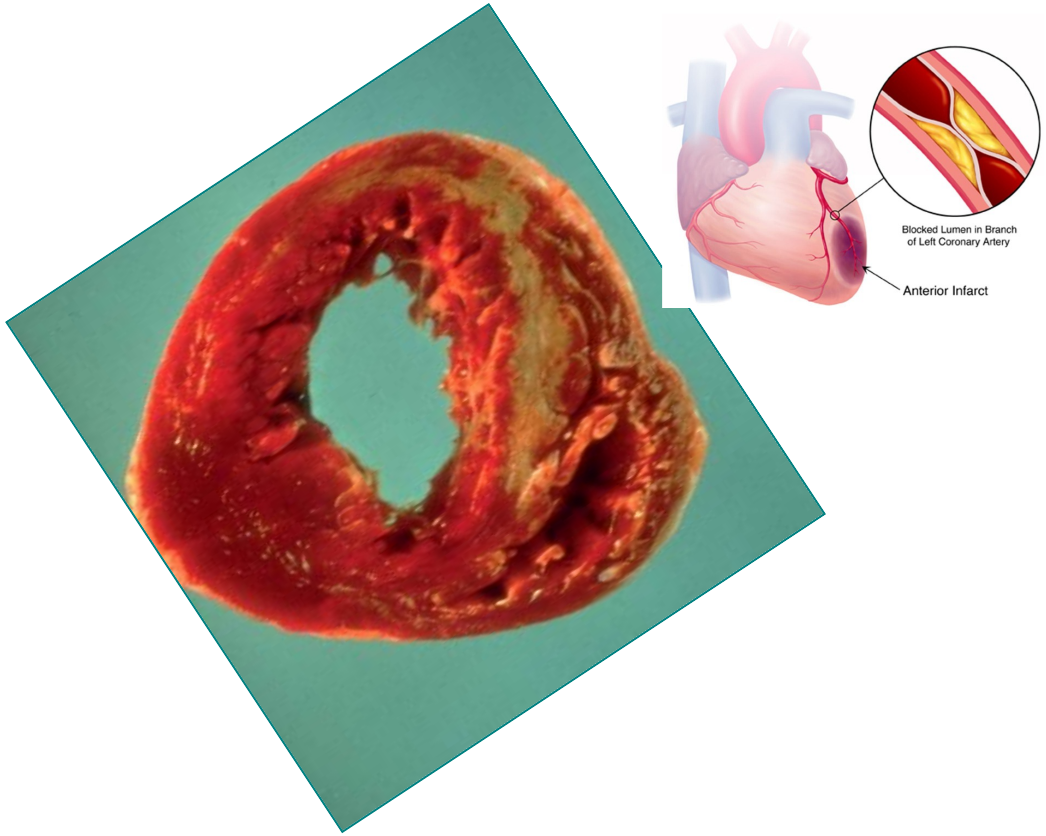


Normal Mild Moderate Severe
Atherosclerosis

Pathology: HTN Effects on Large-Medium Arteries



Infarct in left Middle Cerebral Artery



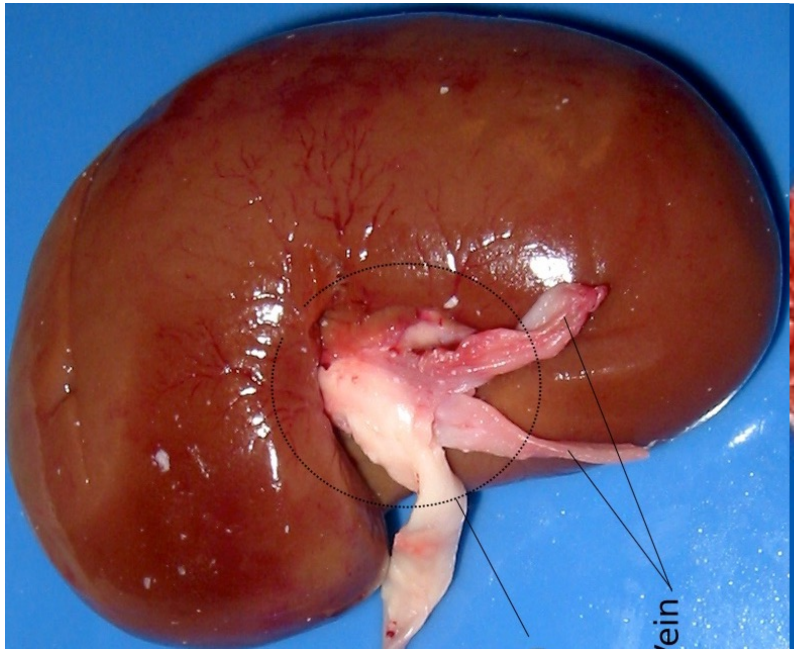
Recent MI in LAD

Pathology: Chronic HTN Effects on Small Arteries and Arterioles

Pathology : Thickened vessel wall → stenotic lumen

Complications : Ischemia

Organs : Kidney (common cause of renal failure)
'benign nephrosclerosis'



Pathology: Chronic HTN Effects on Small Arteries and Arterioles

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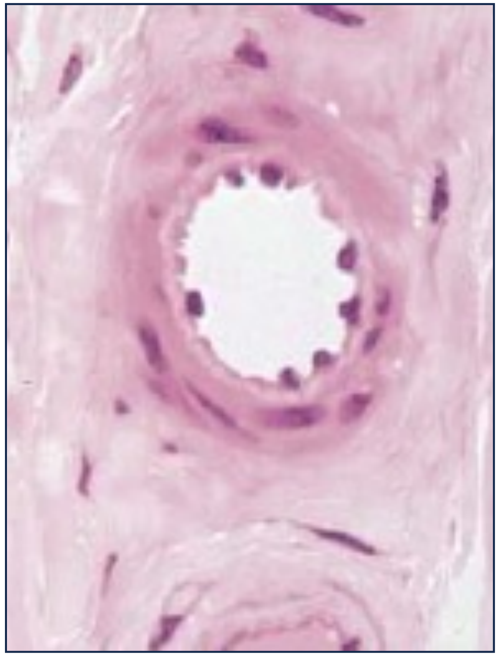
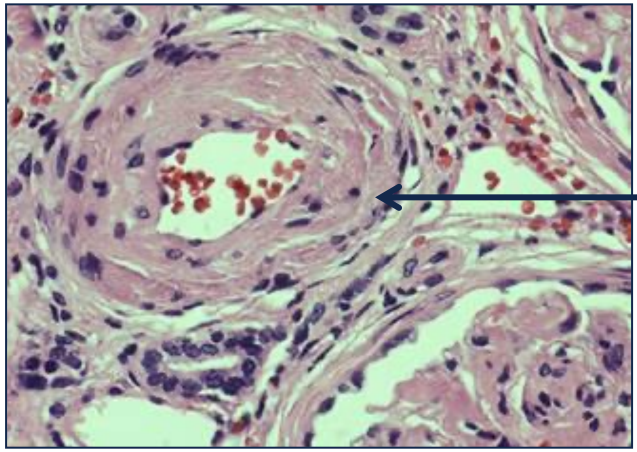
Normal arteriole



Effects of HTN

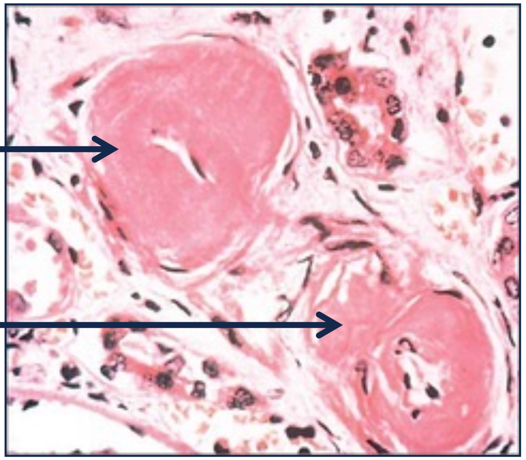


Arteriosclerosis

Thickened vessel wall with increased smooth muscle and/or hyaline (amorphous pink) material = collagen, elastin, plasma proteins

+

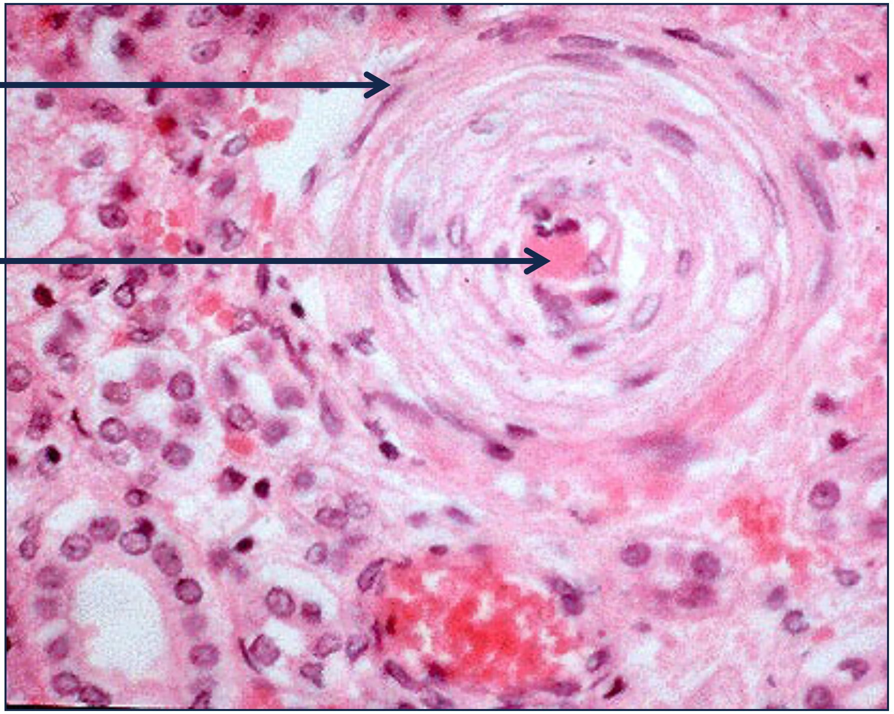
Stenotic lumen

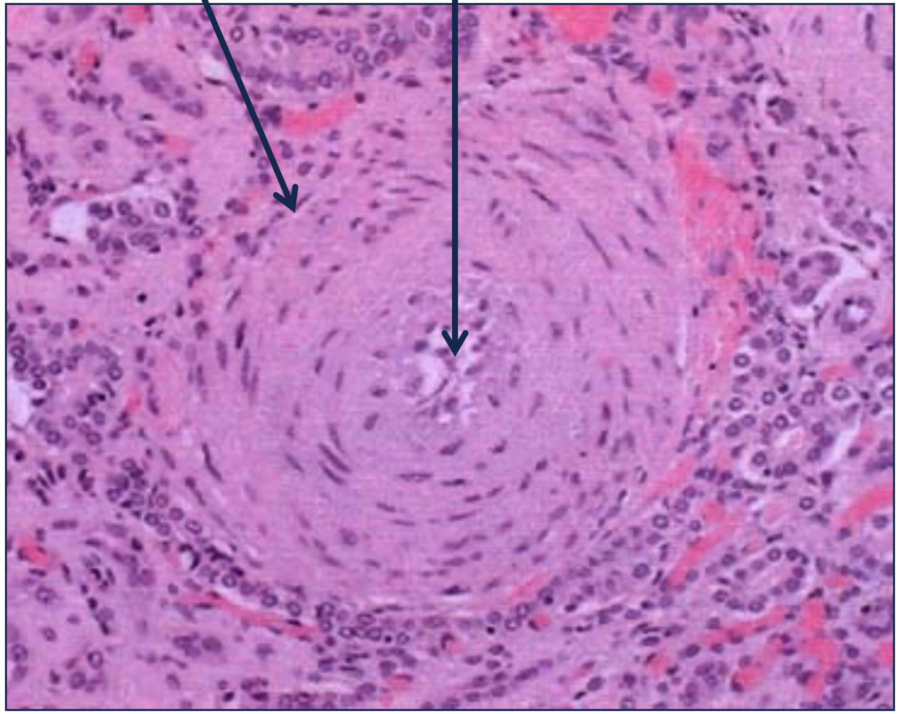


Hyaline Arteriolosclerosis

Pathology: Severe HTN Effects on Microvasculature

Thickened wall with
↑ layers of smooth muscle
cells = ‘Onion Skinning or
Malignant Arteriosclerosis’
+
Stenotic lumen





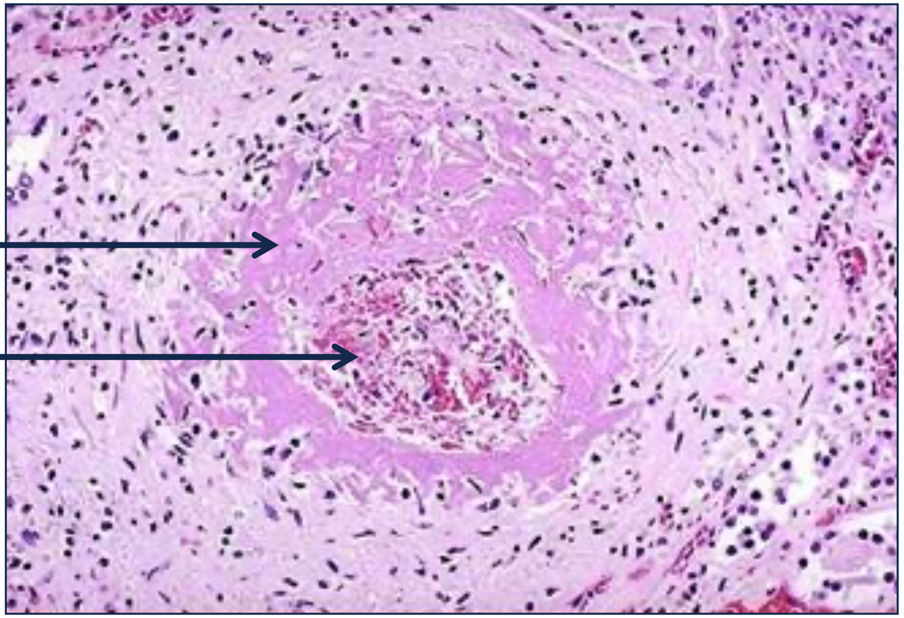
Pathology: Severe HTN Effects on Microvasculature

Necrotic, thickened wall with insudated plasma proteins including fibrin = 'Fibrinoid Necrosis'

+

Thrombus

-leads to acute organ damage associated with a HTN emergency



Blood Pressure and Hypertension - Summary

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1. Systemic blood pressure regulation is a complex process that involves many organs of the body, and effector molecules, including the heart, blood vessels, autonomic nervous system and renin-angiotensin system.
2. Risk factors for HTN are common, and the incidence of HTN is high.
3. Essential HTN doesn't have a specific identifiable cause, secondary HTN does.
4. HTN is a silent killer, not being overtly manifest until usually severe consequences occur.
5. HTN damages the heart, large vessels, small vessels, and may lead to end organ failure, especially the kidney.

Blood Pressure and Hypertension

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Questions??

Template

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HTN – Case Study

MK is a 51-year-old Caucasian male who is 6 feet tall and weighs 275 pounds (BMI 37.3) with an abnormal distribution of weight around his abdomen. He does not regularly exercise, does not like to cook, and eats fast food three to five times during the week. He has smoked one pack per day since the age of 20 (31 pack years). He has a history of hyperlipidemia, but is unable to afford his medication (atorvastatin), and has not taken since he was diagnosed 5 years ago. He has no current diagnosed medical problems. He became concerned and came to the emergency department because he is more easily fatigued and has had a headache the past three days that has not improved. He owns his own auto mechanic business. He has no health insurance. His father had hypertension and died of a myocardial infarction (MI) at the age of 50.

HTN – Case Study

Current Assessment:	
GENERAL APPEARANCE:	Appears uncomfortable, body tense with occasional grimacing
RESP:	Breath sounds clear with equal aeration bilaterally ant/post, non-labored respiratory effort
CARDIAC:	Pink, warm and dry, no edema, heart sounds regular–S1S2, pulses bounding, equal with palpation at radial/pedal/post-tibial landmarks
NEURO:	Alert and oriented to person, place, time, and situation (x4)
GI:	Abdomen soft/non-tender, bowel sounds audible per auscultation in all 4 quadrants
GU:	Voiding without difficulty, urine clear/yellow
SKIN:	Skin integrity intact, skin turgor elastic with no tenting

Current VS:	**P-Q-R-S-T Pain Assessment (5th VS):**	
T: 98.9 F/37.2 C (oral)	**P**rovoking/Palliative:	Nothing/Nothing
P: 88 (regular)	**Q**uality:	Ache
R: 20	**R**egion/Radiation:	Global head ache (HA)
BP: 220/118	**S**everity:	8/10
O2 sat: 95% room air	**T**iming:	Continuous

Chest X-ray: enlarged cardiac silhouette
CBC: normal
Metabolic labs: high blood and urine glucose, poor kidney function

HTN – Case Study

What are some major factors that play a part in determining blood pressure?

What formula defines blood pressure?

HTN – Case Study

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What are some major factors that play a part in determining blood pressure?

Arteriole tone, heart contractility, blood volume

What formula defines blood pressure?

Systemic vascular resistance X cardiac output = BP

HTN – Case Study

What are some of MK's risk factors for Hypertension?

HTN – Case Study

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What are some of MK's risk factors for Hypertension?

Obesity/abdominal fat (metabolic syndrome/diabetes)
Sedentary lifestyle/poor diet
High stress job
Family history
Tobacco use

Hyperlipidemia – exacerbates effects of HTN, not in itself a risk factor

HTN – Case Study

MK's HTN was verified over the next several weeks, and further workup revealed no identifiable cause for the HTN. Treatment was initiated for his HTN as well as his hyperlipidemia and diabetes. However, he had no health insurance and was therefore non-compliant with his medications because he "felt fine," so he stopped seeing his physician.

What type of HTN does MK have?
What potential manifestations of HTN does MK have?

HTN – Case Study

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MK’s HTN was verified over the next several weeks, and further workup revealed no identifiable cause for the HTN. Treatment was initiated for his HTN as well as his hyperlipidemia and diabetes. However, he had no health insurance and was therefore non-compliant with his medications because he “felt fine,” so he stopped seeing his physician.

What type of HTN does MK have? Essential vs secondary

What potential manifestations of HTN does MK have? Chronic kidney disease

HTN – Case Study

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Three years later, MK complained of a severe headache one morning at work, and several minutes later began to slur his speech, and lose function of his right arm and leg.

What is happening to MK?

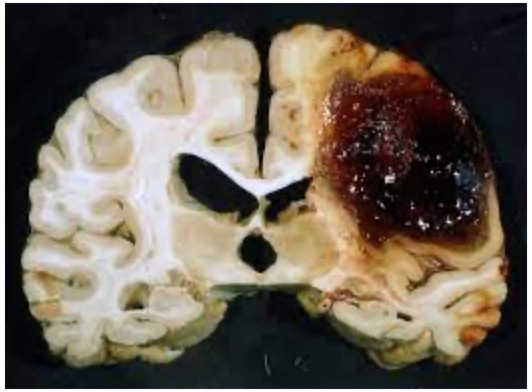
What causes it?

What vascular changes in the brain are associated with it?

What other vascular changes are prevalent in HTN?

HTN – Case Study

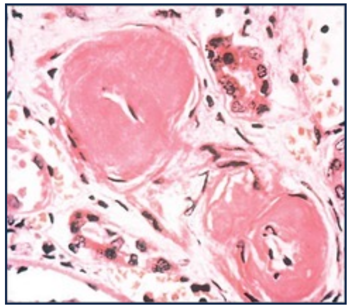
Three years later, MK complained of a severe headache one morning at work, and several minutes later began to slur his speech, and lose function of his right arm and leg.

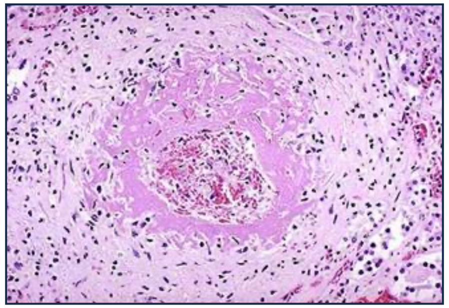


What is happening to MK? He's having a stroke

What causes it? Blood vessel rupture or blockage

What vascular changes in the brain are associated with it? Arteriolosclerosis and fibrinoid necrosis





What other vascular changes are prevalent in HTN? Atherosclerosis