

ARTERIAL BLOOD PRESSURE



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LECTURE OBJECTIVES

- Define Arterial blood pressure
- Systolic and Diastolic blood pressure
- Normal values of Systolic and Diastolic blood pressure
- Hypotension and Hypertension
- Physiological significance
- Describe physiological variation in arterial blood pressure.
- Explain the effect of gravity on arterial blood pressure.
- Pulse pressure, Mean Arterial pressure
- Describe how BP is measured
- Clinical features and complications of Hypertension

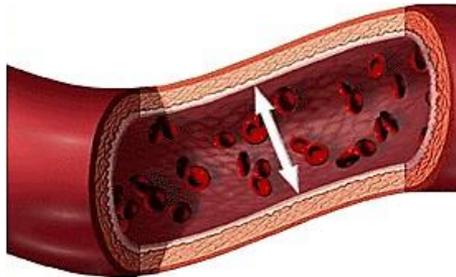
ARTERIAL BLOOD PRESSURE

The pressure / force exerted by the blood against any unit area of the vessel wall is called Blood Pressure.

Standard Units of Blood Pressure

Blood pressure is mainly measured in: Millimeters of mercury (mm Hg)
Occasionally, BP is measured in: Centimeters of water (cm H₂O)

One millimeter of mercury pressure equals 1.36 centimeters of water pressure because the specific gravity of mercury is 13.6 times that of water, and 1 centimeter is 10 times as great as 1 millimeter.



ARTERIAL BLOOD PRESSURE

Systolic Blood Pressure:

The force exerted by the blood against any unit area of the vessel wall while heart is contracting (Systole) is called Systolic Blood Pressure.

120 mmHg

Diastolic Blood Pressure:

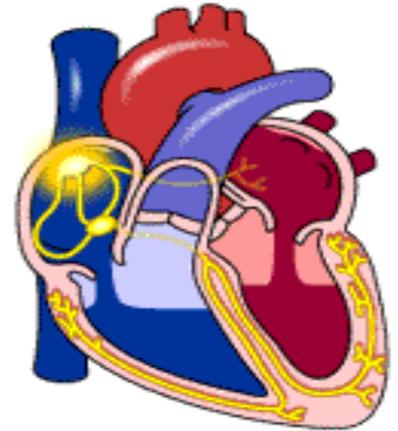
The force exerted by the blood against the unit area of the vessel wall while heart is relaxing (Diastole)

80 mmHg

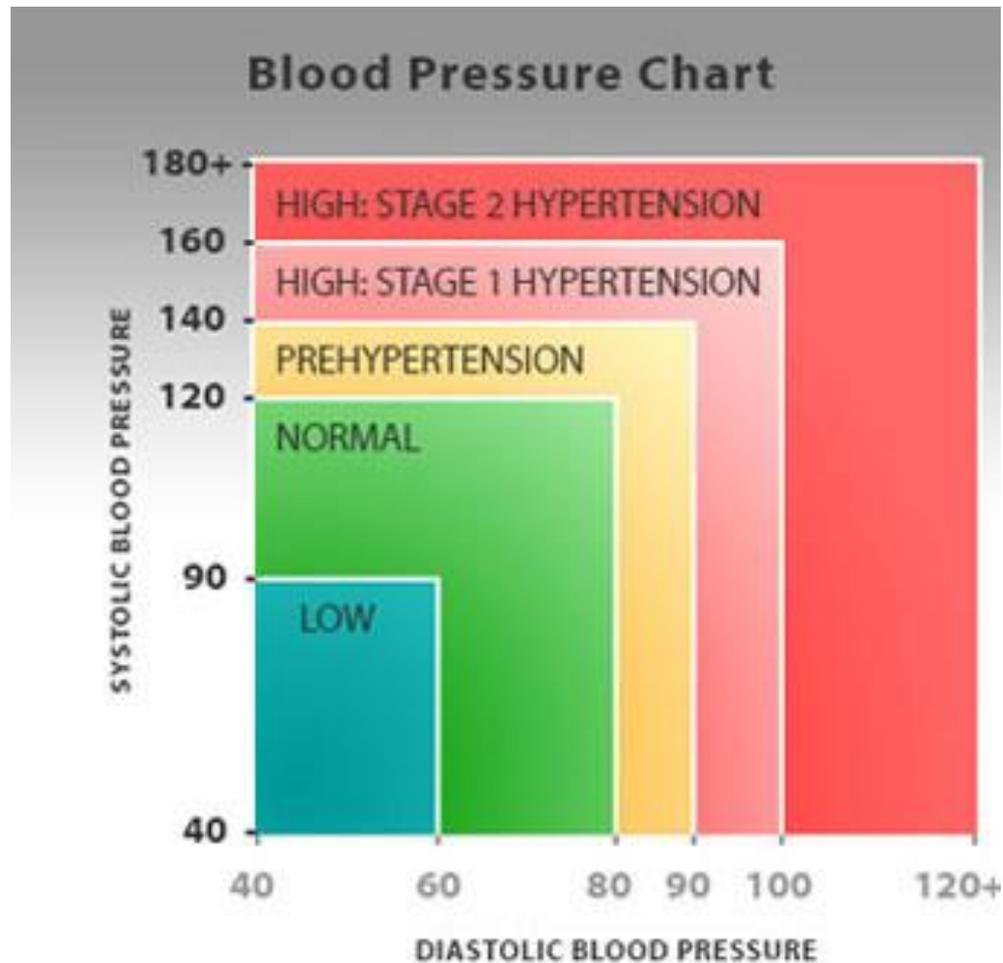
Average Normal Arterial Pressure:

80-120 mmHg systolic

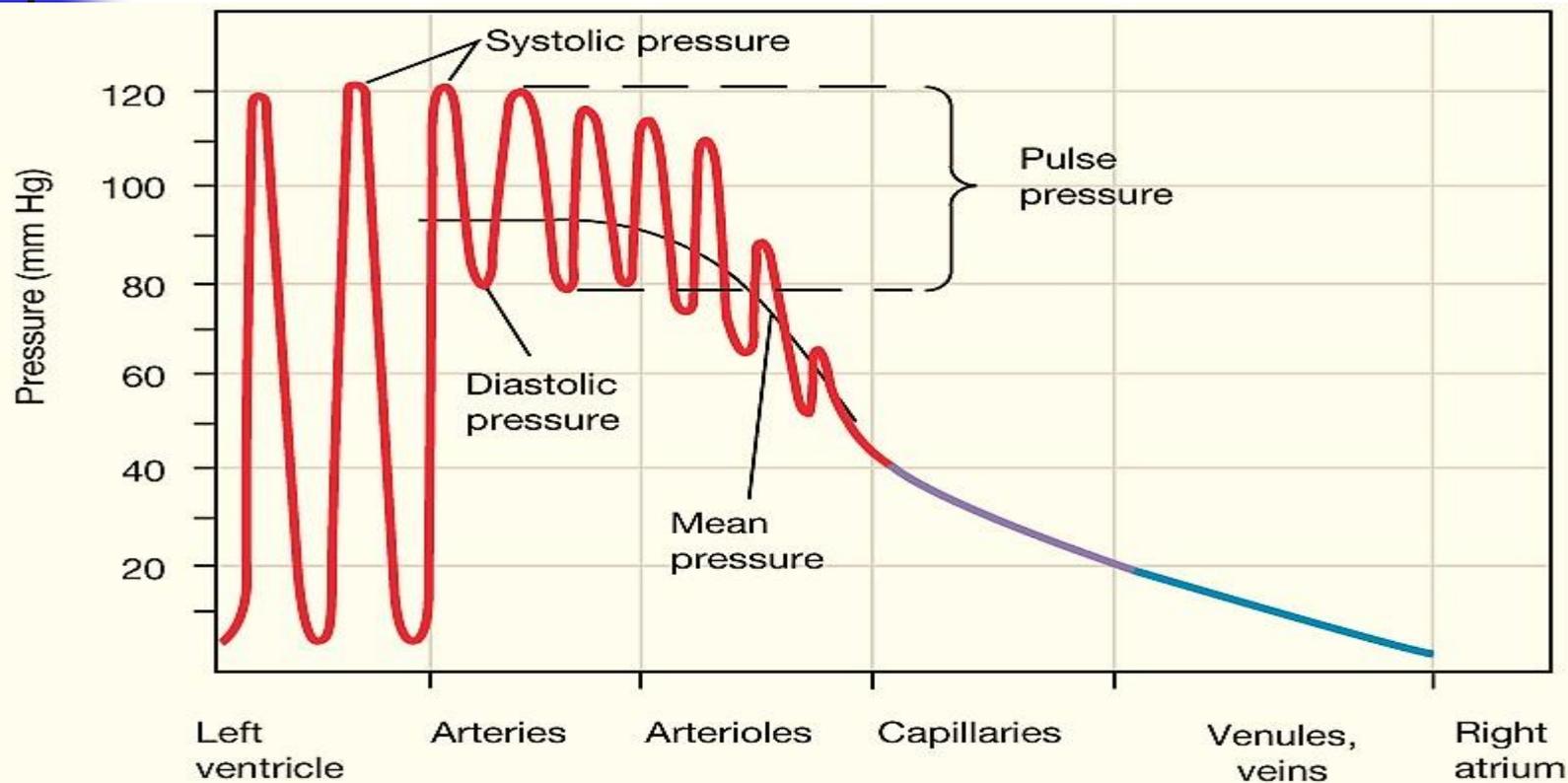
60-80 mmHg diastolic



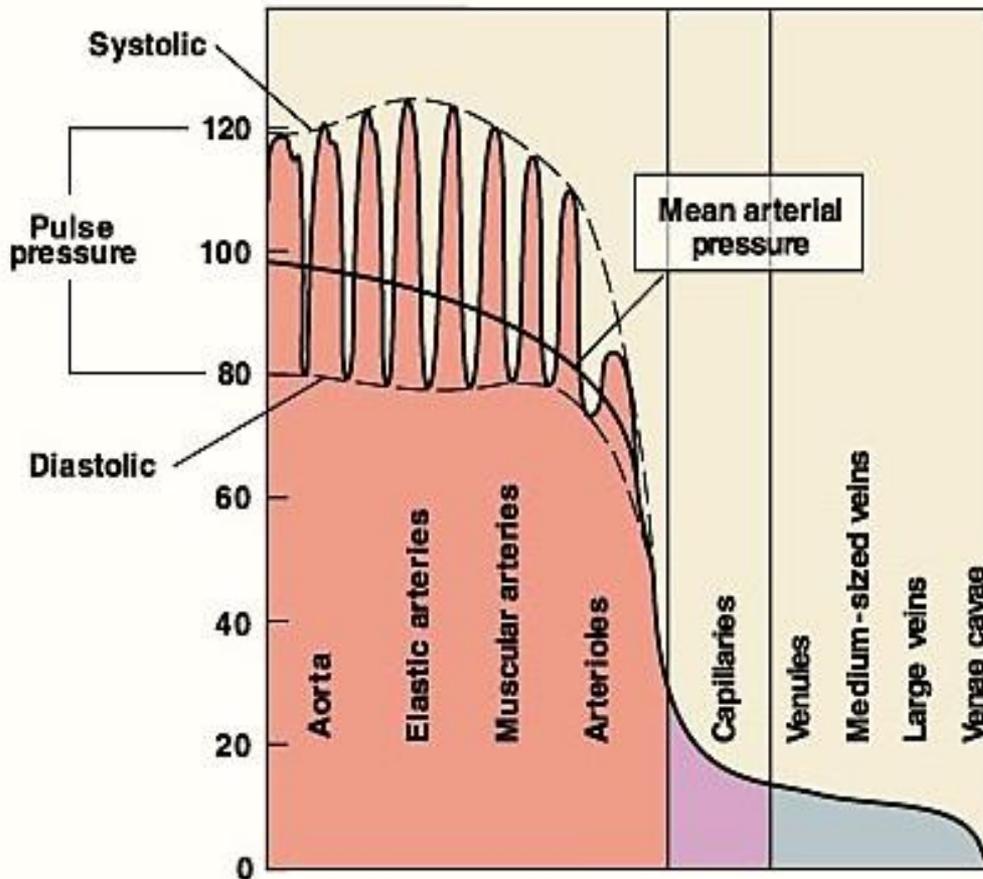
ARTERIAL BLOOD PRESSURE



ARTERIAL BLOOD PRESSURE



ARTERIAL BLOOD PRESSURE IN DIFFERENT PARTS OF THE CIRCULATORY SYSTEM



Highest at the heart.

↓ over distance

↓ 90% from aorta to vena cava

Greatest pressure drop occurs in
arterioles

No great fluctuations in capillaries &
veins

ARTERIAL BLOOD PRESSURE IN DIFFERENT PARTS OF THE CIRCULATORY SYSTEM

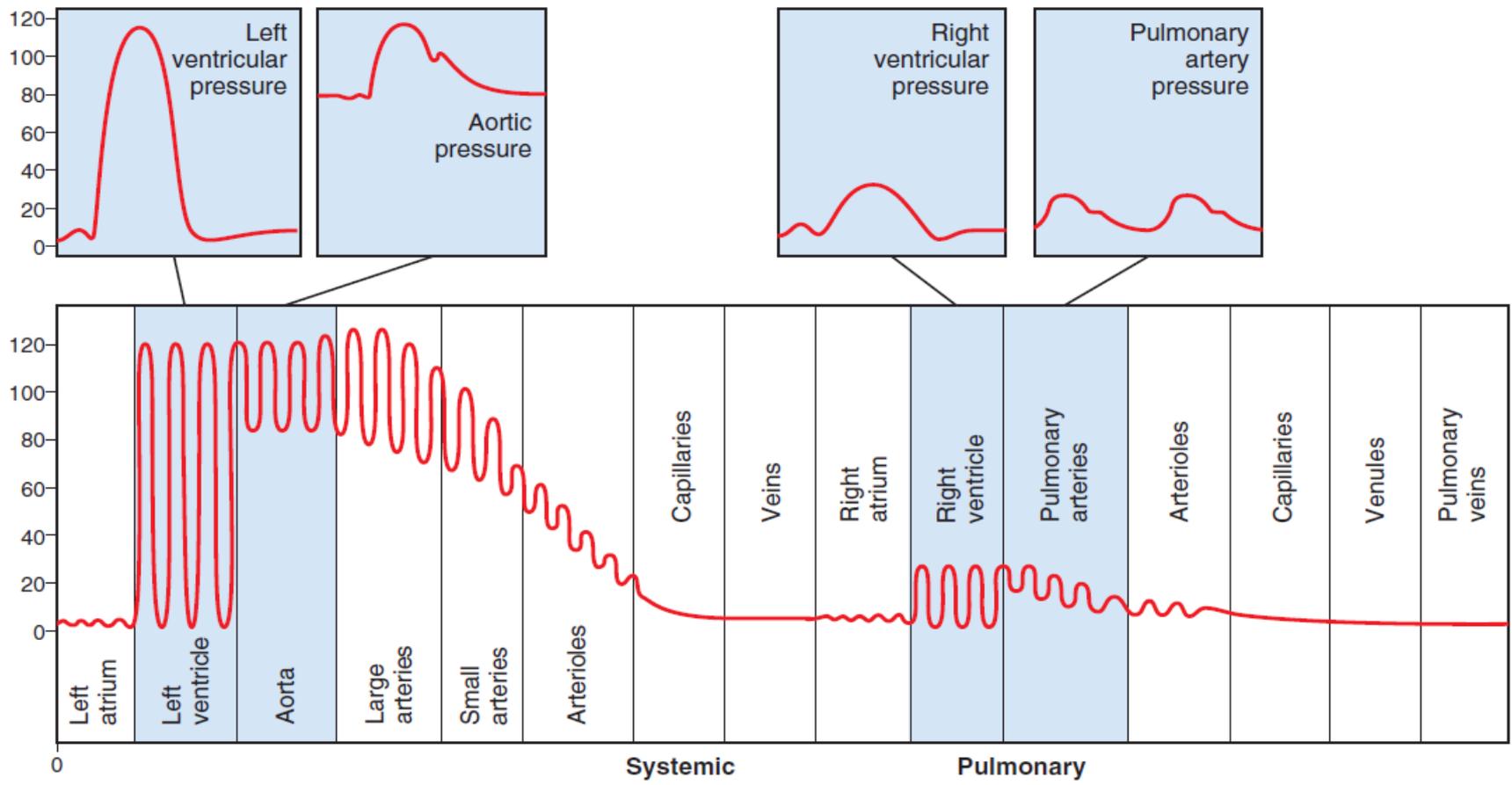
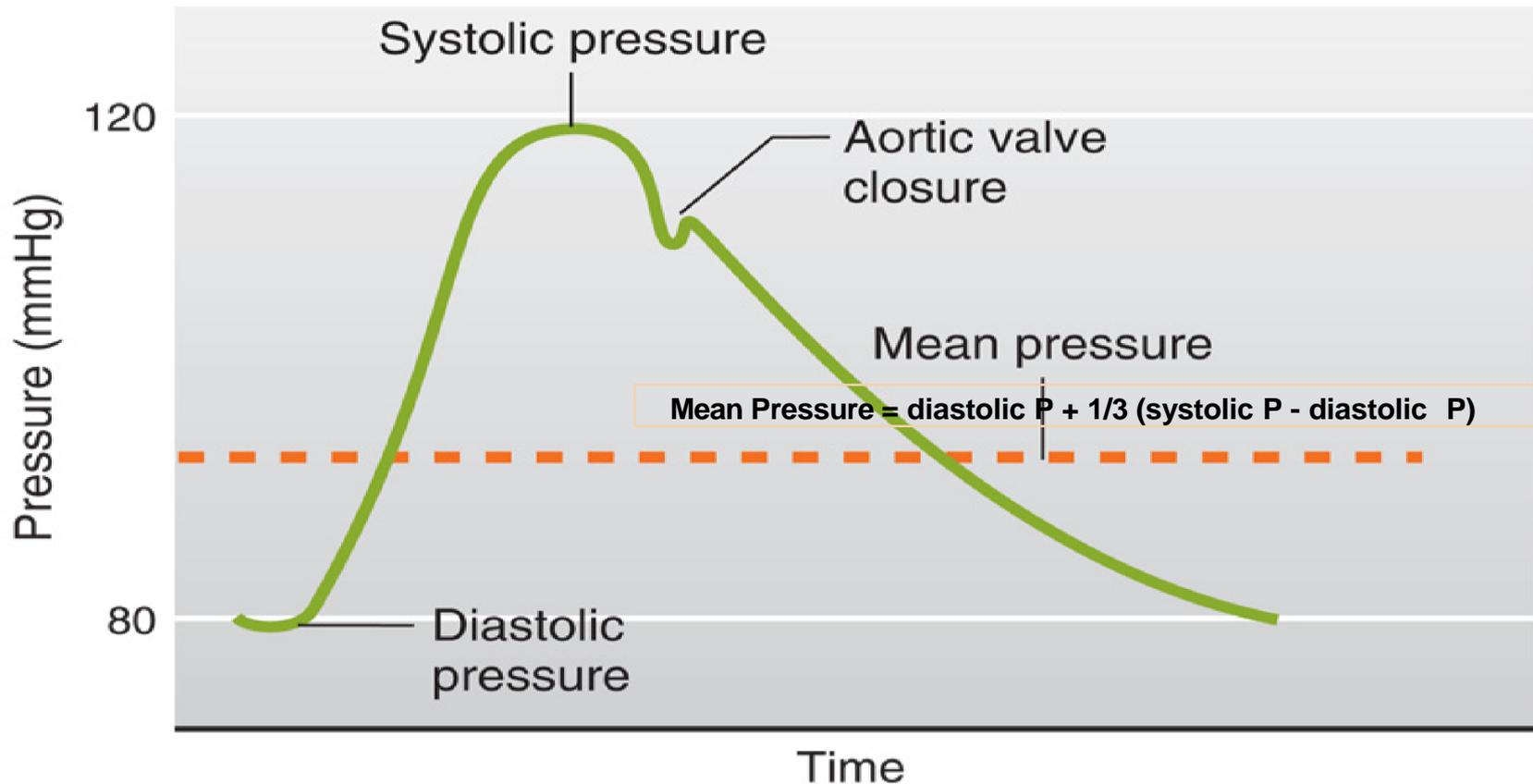
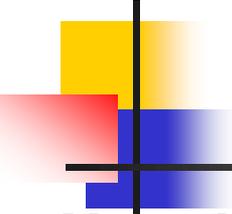


Figure 14-2. Normal blood pressures in the different portions of the circulatory system when a person is lying in the horizontal position. Guyton and Hall, pp 171

ARTERIAL BLOOD PRESSURE





MEAN ARTERIAL BLOOD PRESSURE

Mean Arterial Pressure:

The average of the arterial pressures measured in millisecond over a period of time. It is responsible for driving blood into the tissues throughout the cardiac cycle. It is better indicator of perfusion to vital organs than systolic blood pressure. It is not equal to the average of systolic and diastolic pressure.

To calculate a mean arterial pressure, double the diastolic blood pressure and add the sum to the systolic blood pressure. Then divide by 3.

For example, if a patient's blood pressure is 83 / 50 mmHg, his MAP would be 61 mm Hg.

$$\text{MAP} = \frac{\text{SBP} + 2 (\text{DBP})}{3}$$

$$\text{MAP} = \frac{83 + 2 (50)}{3}$$

$$\text{MAP} = \frac{83 + 100}{3}$$

$$\text{MAP} = 61$$



MEAN ARTERIAL BLOOD PRESSURE

Another way to calculate the MAP is to first calculate the pulse pressure (subtract the DBP from the SBP) and divide that by 3, then add the DBP:

$$\text{Mean Pressure} = \text{diastolic P} + 1/3 (\text{systolic P} - \text{diastolic P})$$

$$\text{MAP} = 1/3 (\text{SBP} - \text{DBP}) + \text{DBP}$$

$$\text{MAP} = 1/3 (83 - 50) + 50$$

$$\text{MAP} = 1/3 (33) + 50$$

$$\text{MAP} = 11 + 50$$

$$\text{MAP} = 61 \text{ mm Hg}$$

PHYSIOLOGICAL FACTORS AFFECTING ARTERIAL BLOOD PRESSURE

- **Sex:** Male > Female ... (equal at menopause)
- **Age:** (↑) Old age: Atherosclerosis
- **Emotions:** BP (↑) due to neural & hormonal factors.
- **Exercise:** (↑) BP due to ↑ venous return.
- **Hormones:** Some hormones like adrenaline, noradrenaline & thyroid (↑) BP.
- **Gravity:** BP is higher in lower limbs than upper limbs.
- **Stress:** (↑) stress)
- **Sleep:** BP (↓) due to ↓ venous return.
- **Pregnancy:** BP (↑) due to ↑ in metabolism.
- **Temperature:** BP (↓) with heat due to vasodilatation
(↑) with cold due to vasoconstriction
- **Obesity** (↑)

PHYSIOLOGICAL FACTORS AFFECTING ARTERIAL BLOOD PRESSURE

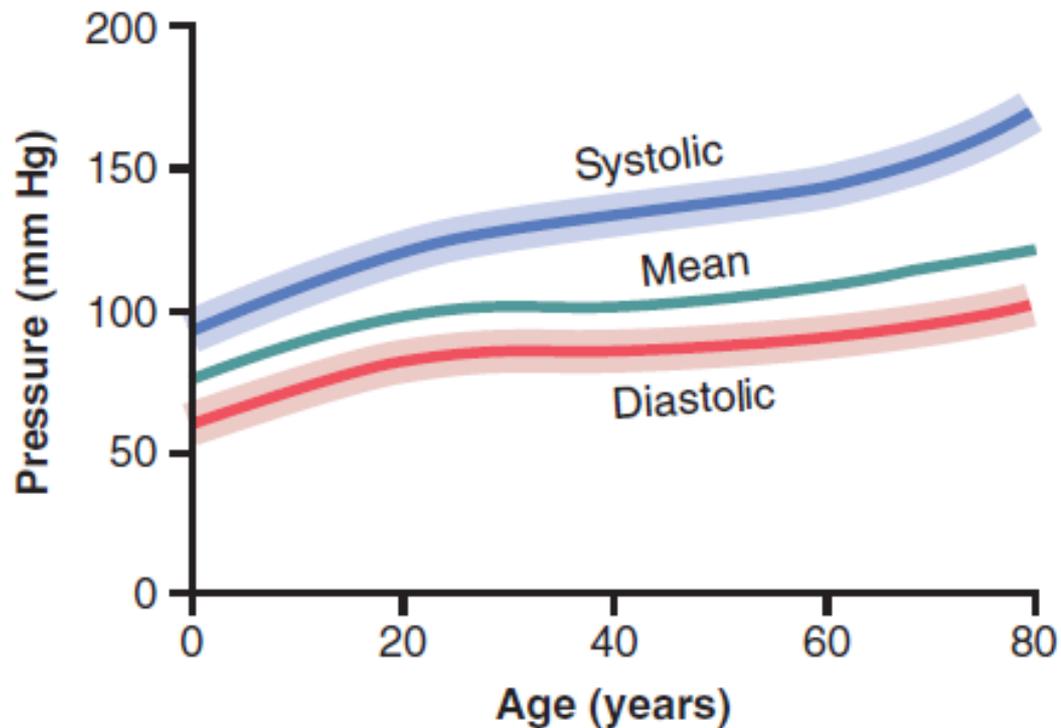
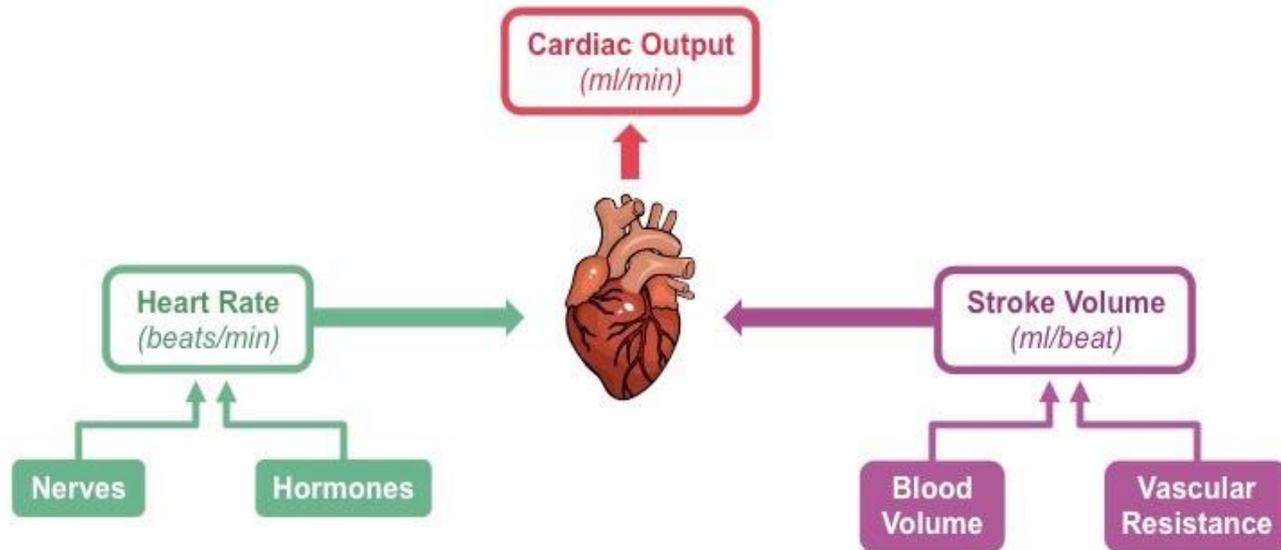


Figure 15-8. Changes in systolic, diastolic, and mean arterial pressures with age. The shaded areas show the approximate normal ranges.

PHYSIOLOGICAL FACTORS AFFECTING ARTERIAL BLOOD PRESSURE

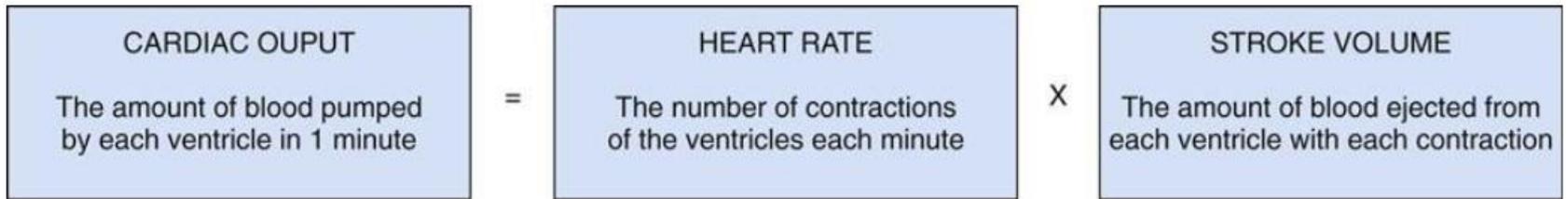


Heart Rate (HR)

Stroke Volume (SV) = EDV – ESV

$$\text{Cardiac Output (CO)} = \text{HR} \times \text{SV}$$

PHYSIOLOGICAL FACTORS AFFECTING ARTERIAL BLOOD PRESSURE



AVERAGE 4900–5000 mL = 70 X 70 mL

CO	=	HR	X	SV
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FACTORS AFFECTING
CARDIAC OUTPUT

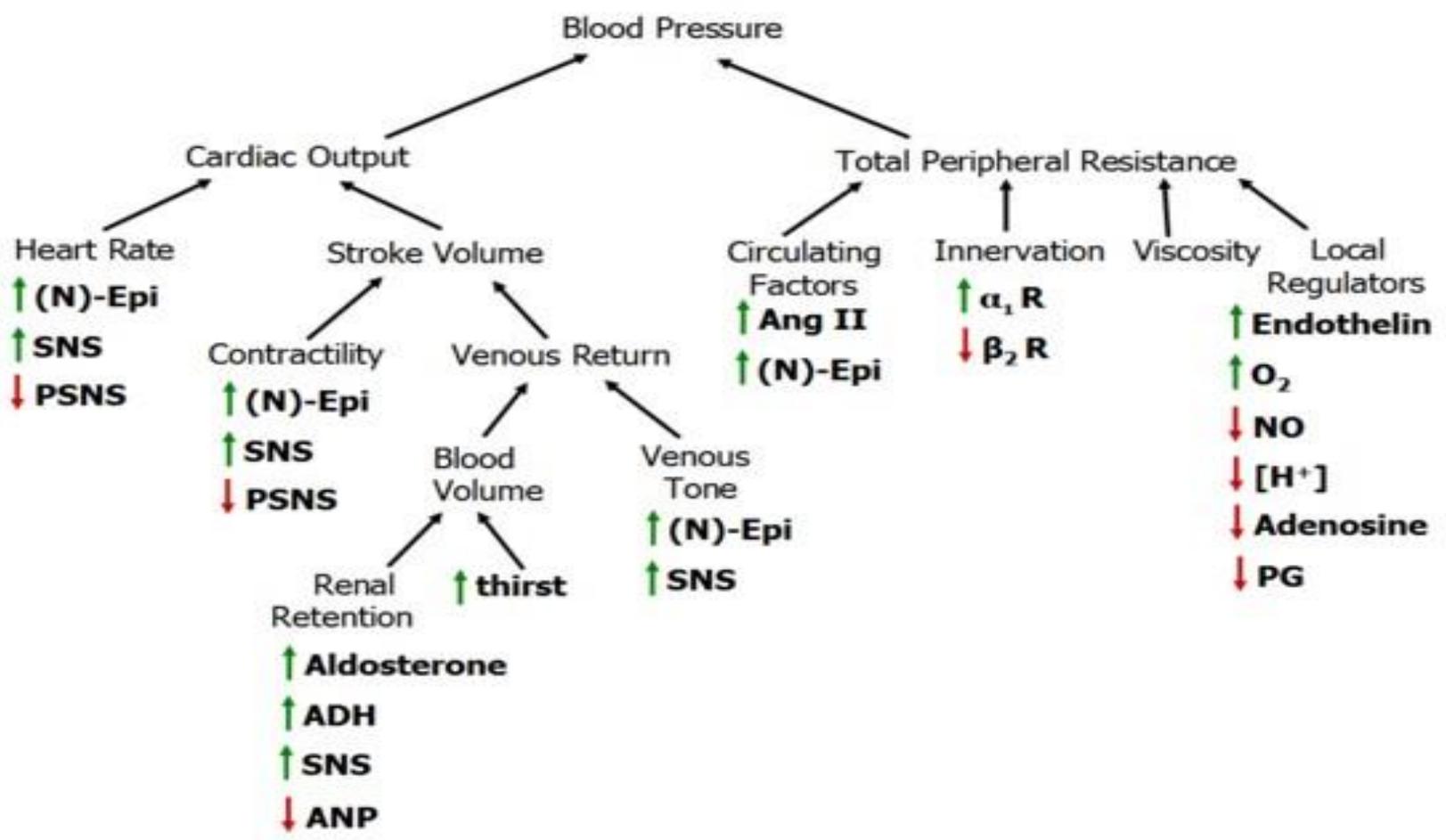
Sympathetic nervous system
Epinephrine

X

Venous return (preload)
Blood volume
Sympathetic nervous system (contractility)
Peripheral resistance (afterload)



PHYSIOLOGICAL FACTORS AFFECTING ARTERIAL BLOOD PRESSURE



PHYSIOLOGICAL FACTORS AFFECTING ARTERIAL BLOOD PRESSURE

Factors determining CO:

1. Stroke volume
2. Heart rate

Cardiac Output (CO)

This is the amount of blood pumped by ventricles per minute

$$\text{Cardiac Output} = \text{Stroke Volume} \times \text{Heart Rate}$$



Cardiac Output (CO)
= Output of ventricles / minute
≈ 5 L/min (av. 5-6 L/min)

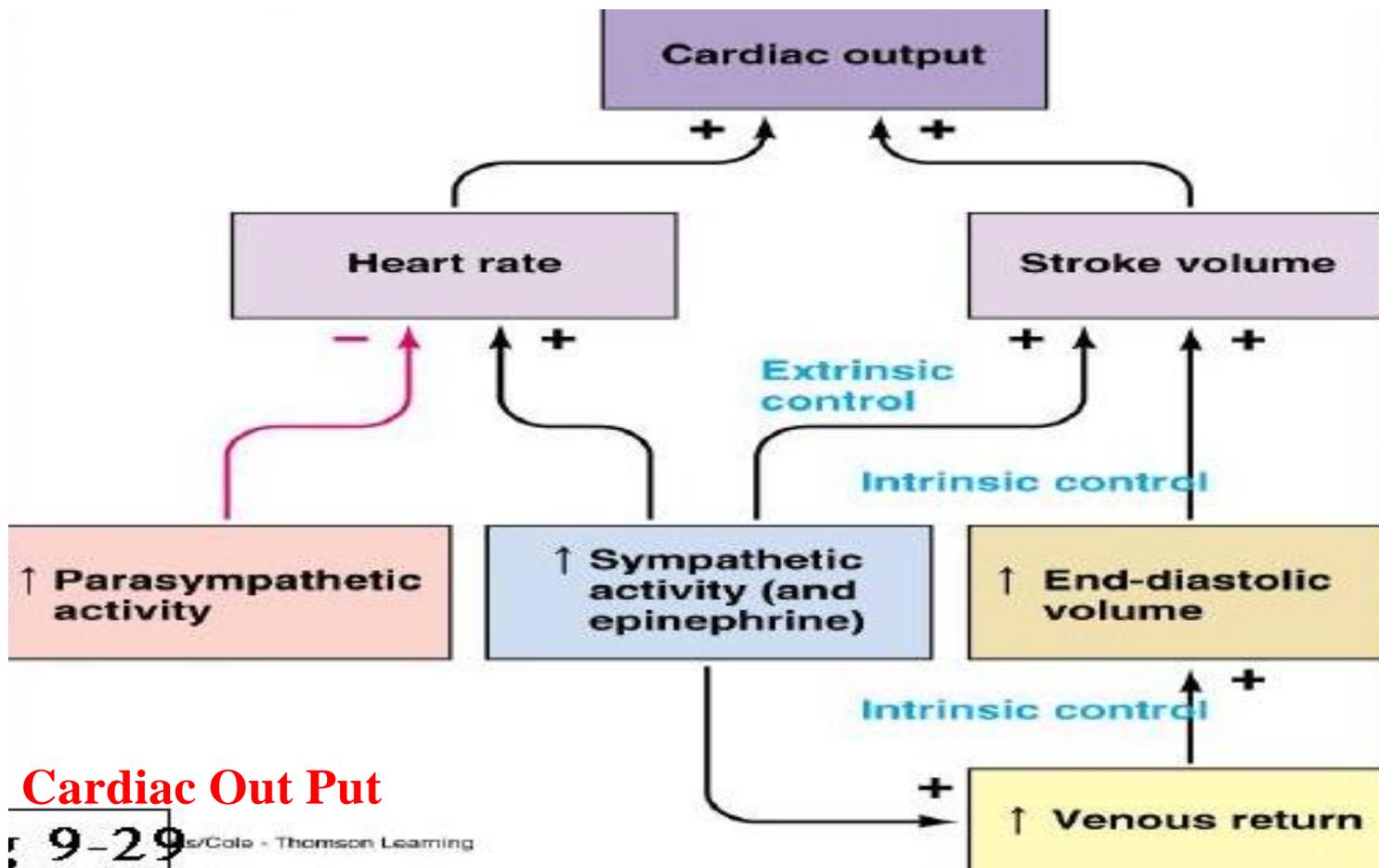


Stroke Volume (SV)
= Output of ventricles / beat
70 ml/beat (av. 70-80 ml/beat)



Heart Rate (HR)
= beats/ minute
≈ 70-75 beats/min (av 60-100 beats/min)

PHYSIOLOGICAL FACTORS AFFECTING ARTERIAL BLOOD PRESSURE



Cardiac Out Put

Total Peripheral Resistance (TPR)

$$R = \frac{\Delta P}{Q}$$

Systemic Circulation:

$$TPR = \frac{\text{Aortic Pressure} - \text{RAP}}{\text{Flow}}$$

$$TPR = \frac{120 - 2}{83.3 \text{ ml/sec (5 L/min)}} \text{ mmHg}$$

$$TPR = 1.41$$

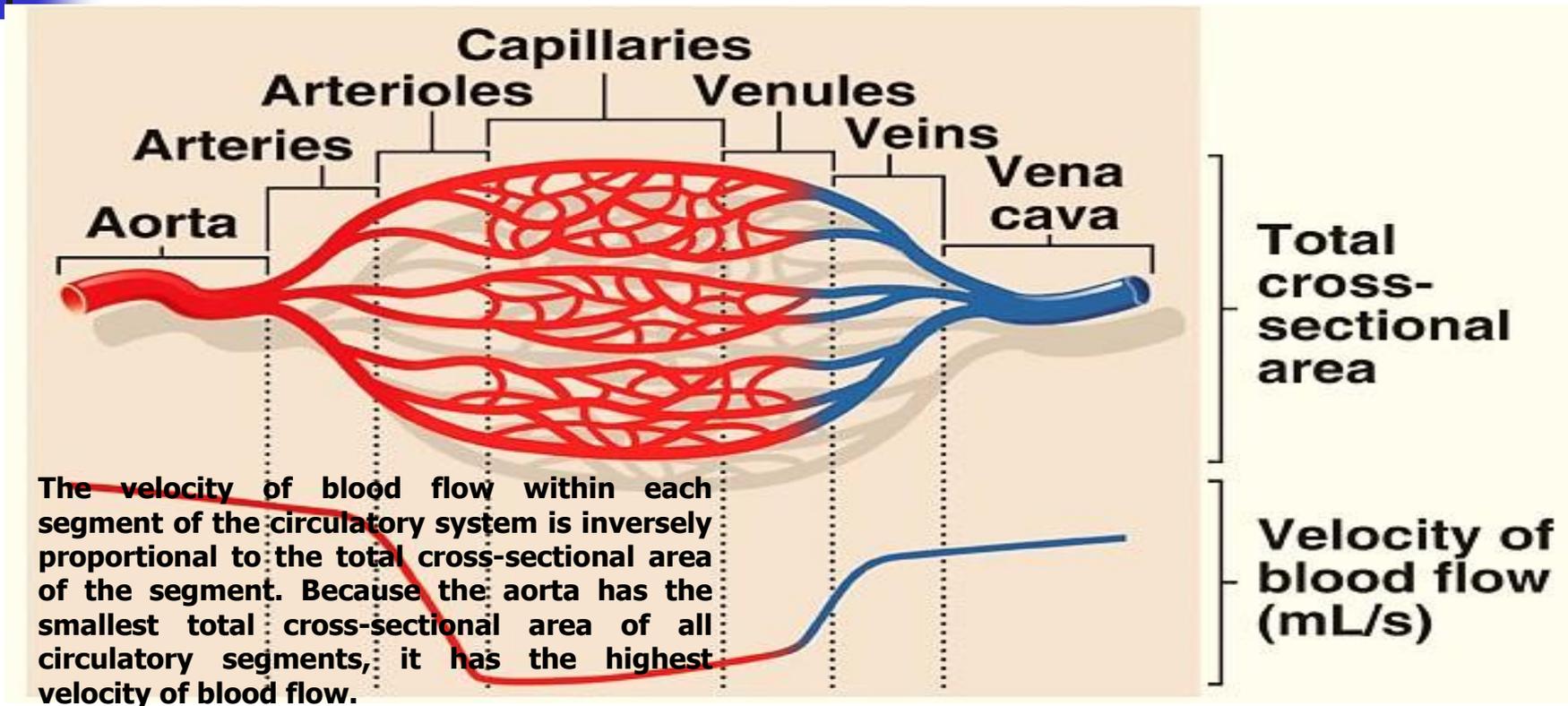
Pulmonary Circulation:

$$\text{Pul. R.} = \frac{\text{Pulmonary Art. P.} - \text{LAP}}{\text{Flow}}$$

$$\text{Pul. R.} = \frac{15 - 3 \text{ mmHg}}{83.3 \text{ ml/sec (5 L/min)}}$$

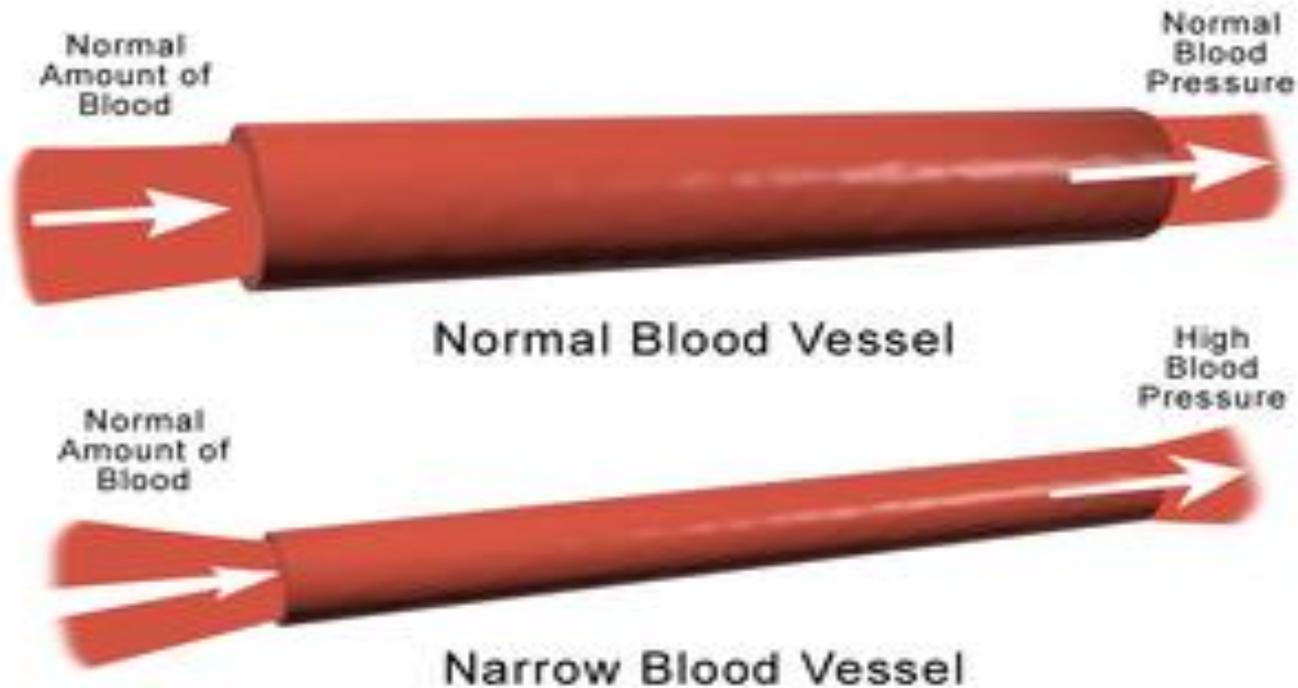
$$\text{Pul. R.} = 0.14$$

DIAMETER AND BLOOD FLOW

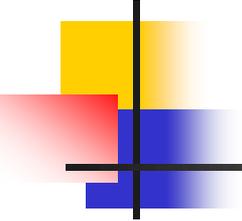


As diameter of vessels ↓, the total cross-sectional area
↑ & velocity of blood flow ↓

Effect of Radius on Pressure



Blood Pressure Blood Flow



BLOOD PRESSURE AND BLOOD VOLUME

Blood Volume:

An increase in blood volume \rightarrow \uparrow CO \rightarrow \uparrow ABP.

A decrease in blood volume as in hemorrhage, dehydration \rightarrow
 \downarrow VR \rightarrow \downarrow CO \rightarrow \downarrow ABP.

Elasticity of blood vessels:

- Changes in the elasticity of large vessels affects ABP.
- In atherosclerosis, decrease in arterial compliance ("hardening of the arteries"). This makes arteries like a tube, during systole, blood is ejected into the arteries, they don't distend as normal and pressure increases significantly \rightarrow \uparrow PP.

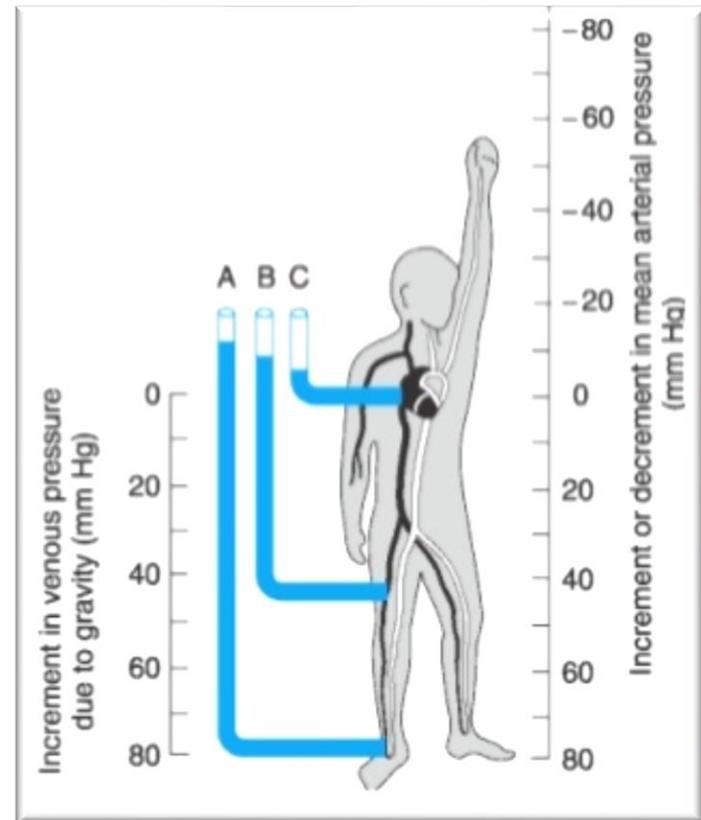
Effect of Gravity on Blood Pressure

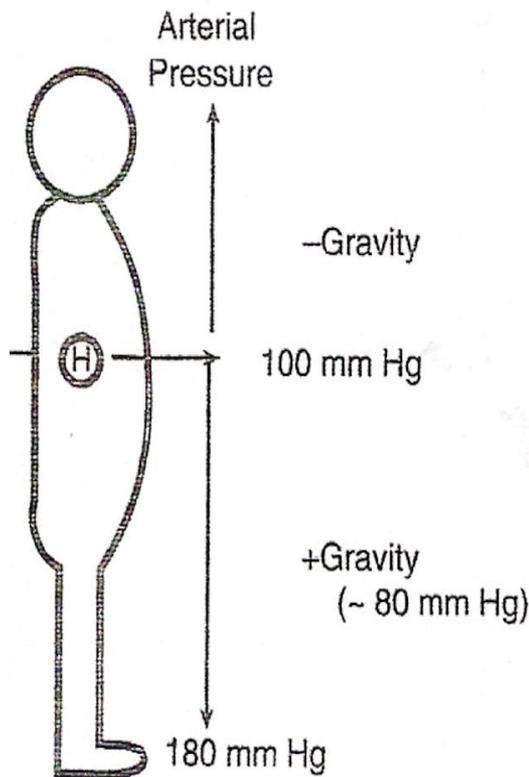
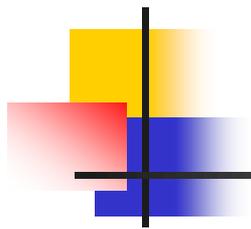
The pressure in any vessel below the level of the heart is increased

Decreased in any vessel above the level of the heart due to the effect of Gravity.

Gravitational effect = 0.77 mmHg/cm at the density of normal blood.

In an adult human in the upright position, if mean MAP at heart level = 100 mmHg , the MAP in an artery at the head (50 cm above heart) = $100 - [0.77 \times 50] = 62 \text{ mmHg}$.





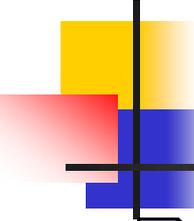
Above heart level

$$50\text{cm} = 100 - [0.77 \times 50] = 62 \text{ mm of Hg}$$

$$1\text{cm} = 0.77 \text{ mm of Hg}$$

Below heart level

$$105\text{cm} = 100 + [0.77 \times 105] = 180 \text{ mm of Hg}$$



Factors affecting vessel diameter

☐ Vasodilator agents:

- Nitric oxide.
- Histamine.
- Atrial natriuretic peptide (ANP).
- Prostacyclin; PGI₂.

☐ Vasoconstrictor agents:

- Norepinephrine.
- Angiotensin II.
- Vasopressin.
- Endothelin-1.
- Thromboxane A₂.

Measurement of Blood Pressure

Two methods: Direct & indirect

Sphygmomanometer:

Types:

- Mercury sphygmomanometer
- Aneroid equipment
- Automatic equipment

Blood Pressure Cuff Size:

- Small – children & small adults
- Average
- Large – overweight & large adults



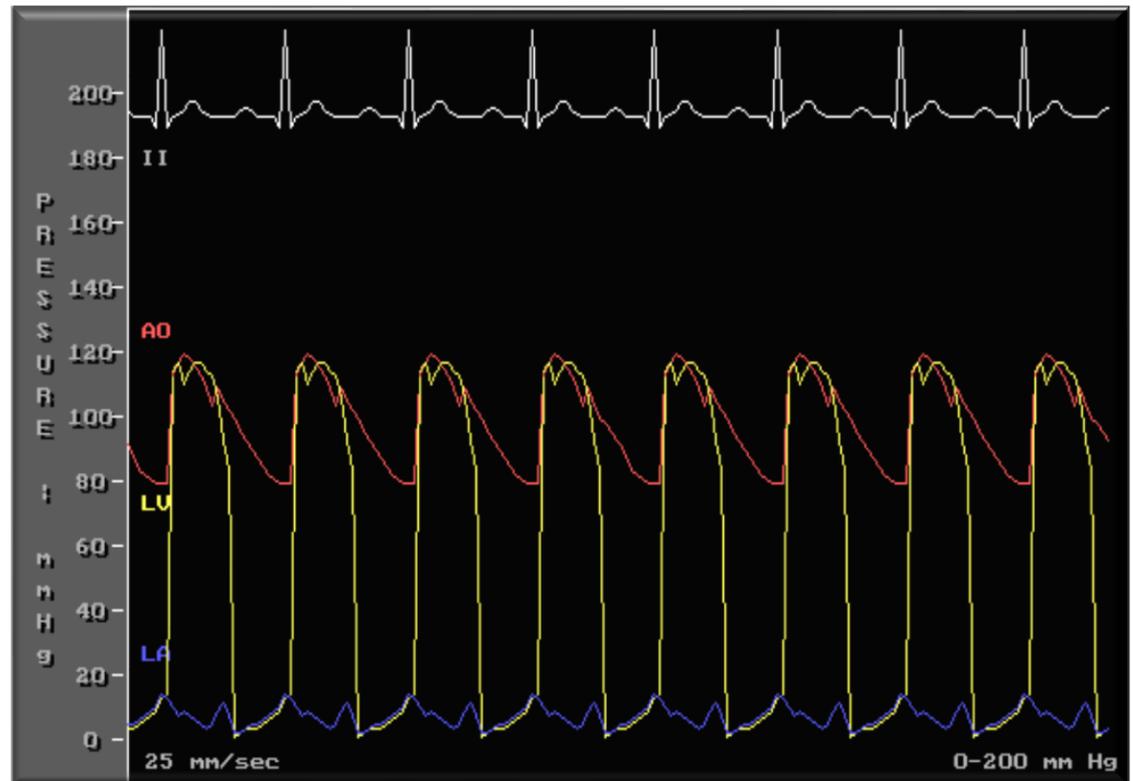
Measurement of Blood Pressure

Direct

Arterial catheter

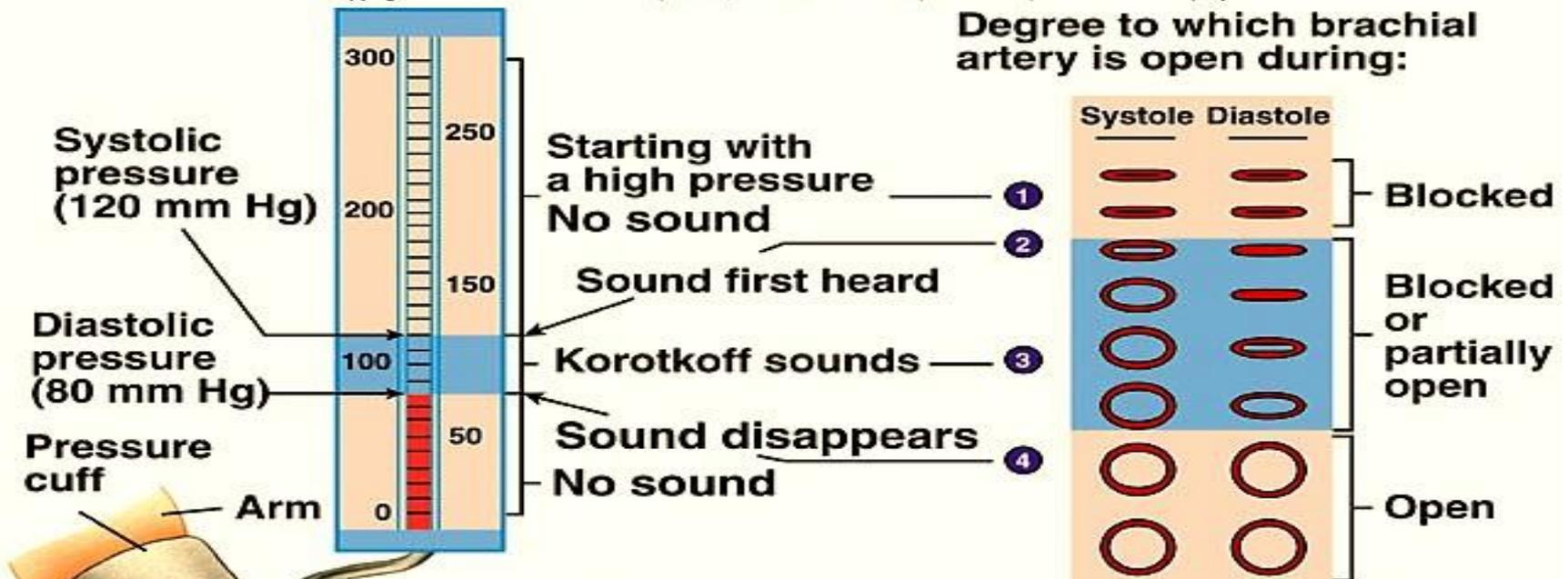
Indirect

Stethoscope and
blood pressure
cuff



Measurement of Blood Pressure

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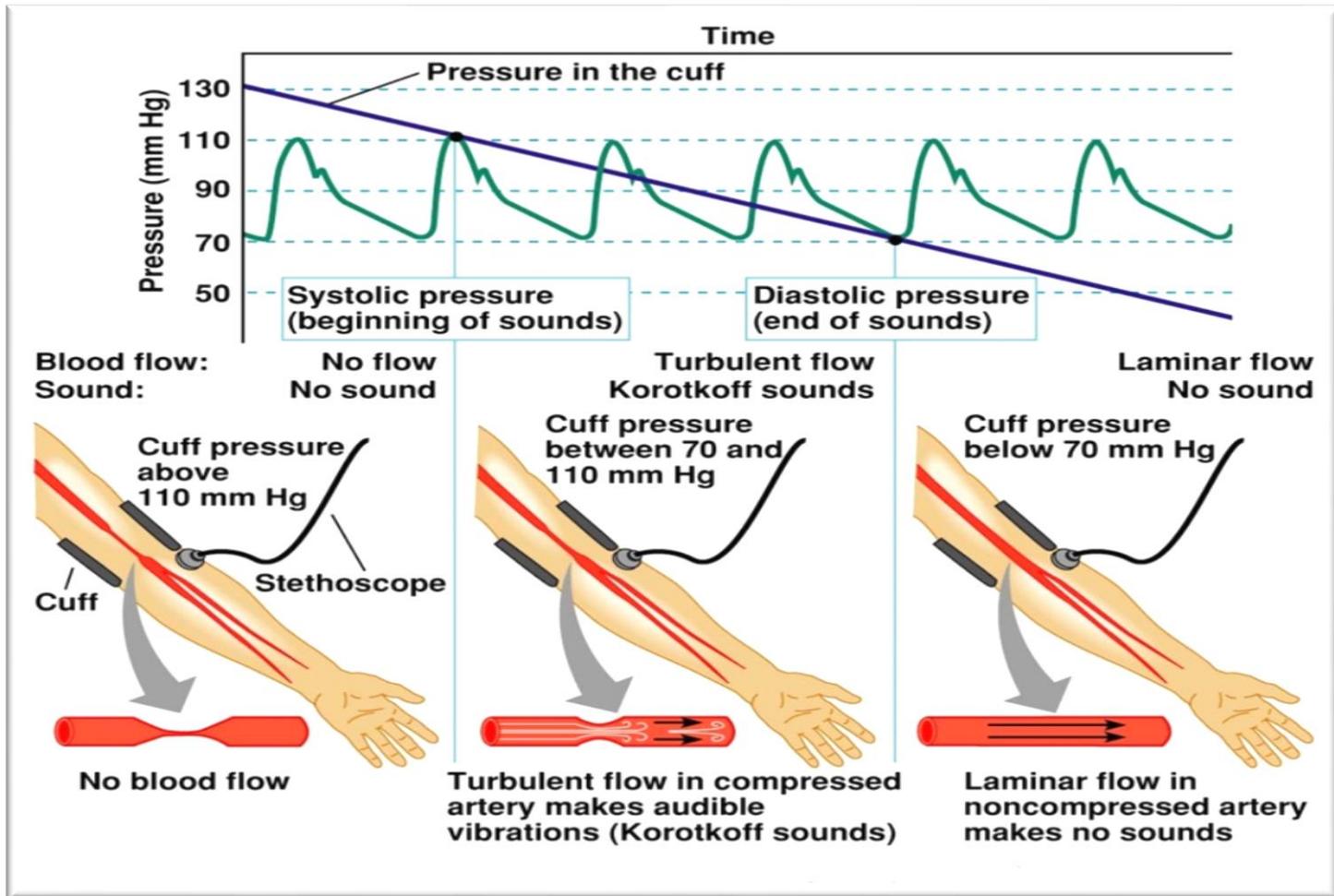


BP is measured by listening for **Korotkoff sounds** produced by turbulent flow in arteries:

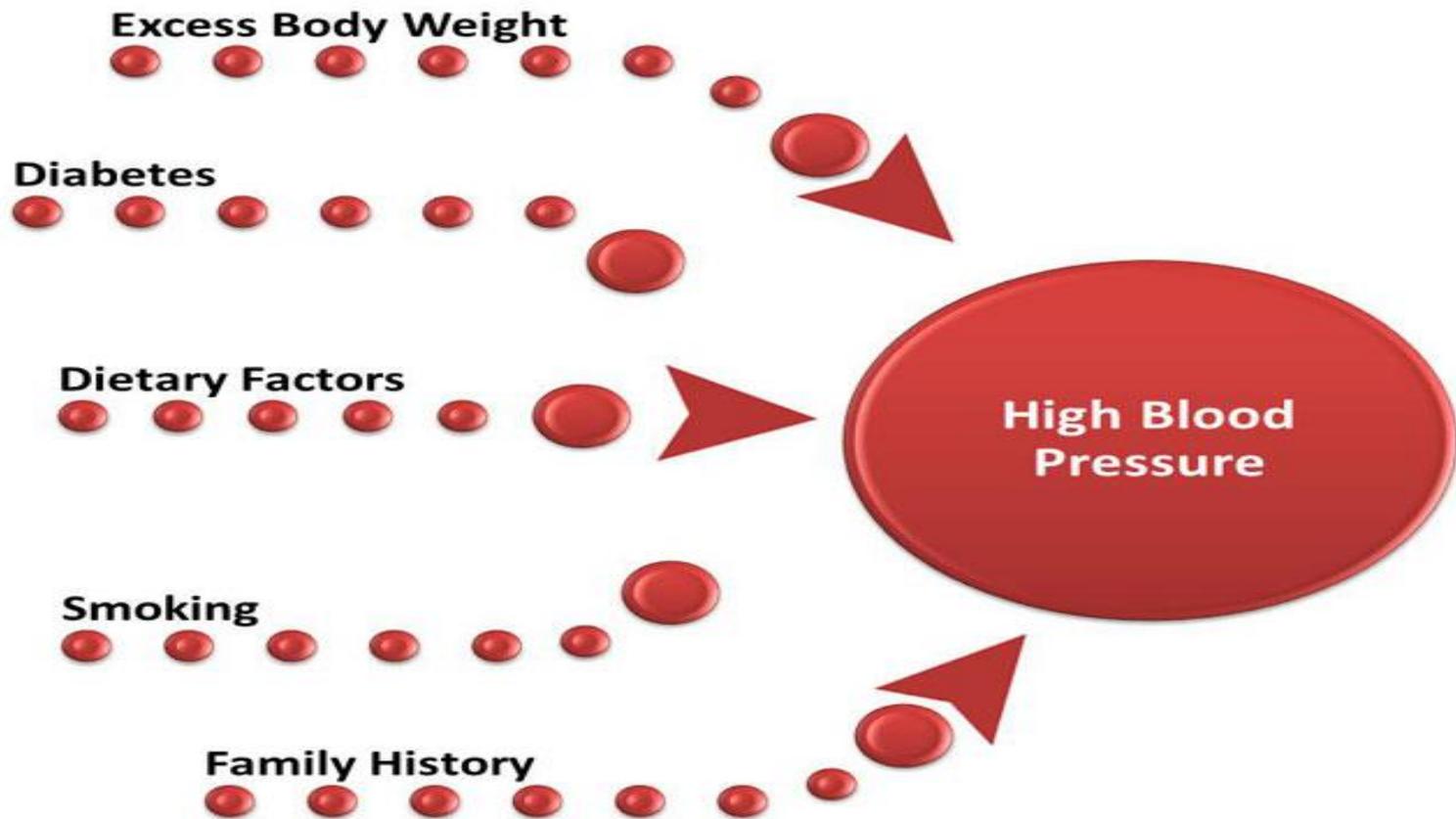
- **Systolic pressure:** When 1st sound is heard.
- **Diastolic pressure:** When last sound is heard.

The tendency for turbulent flow occurs at vascular sites where the velocity of blood flow is high. The aorta has the highest velocity of blood flow.

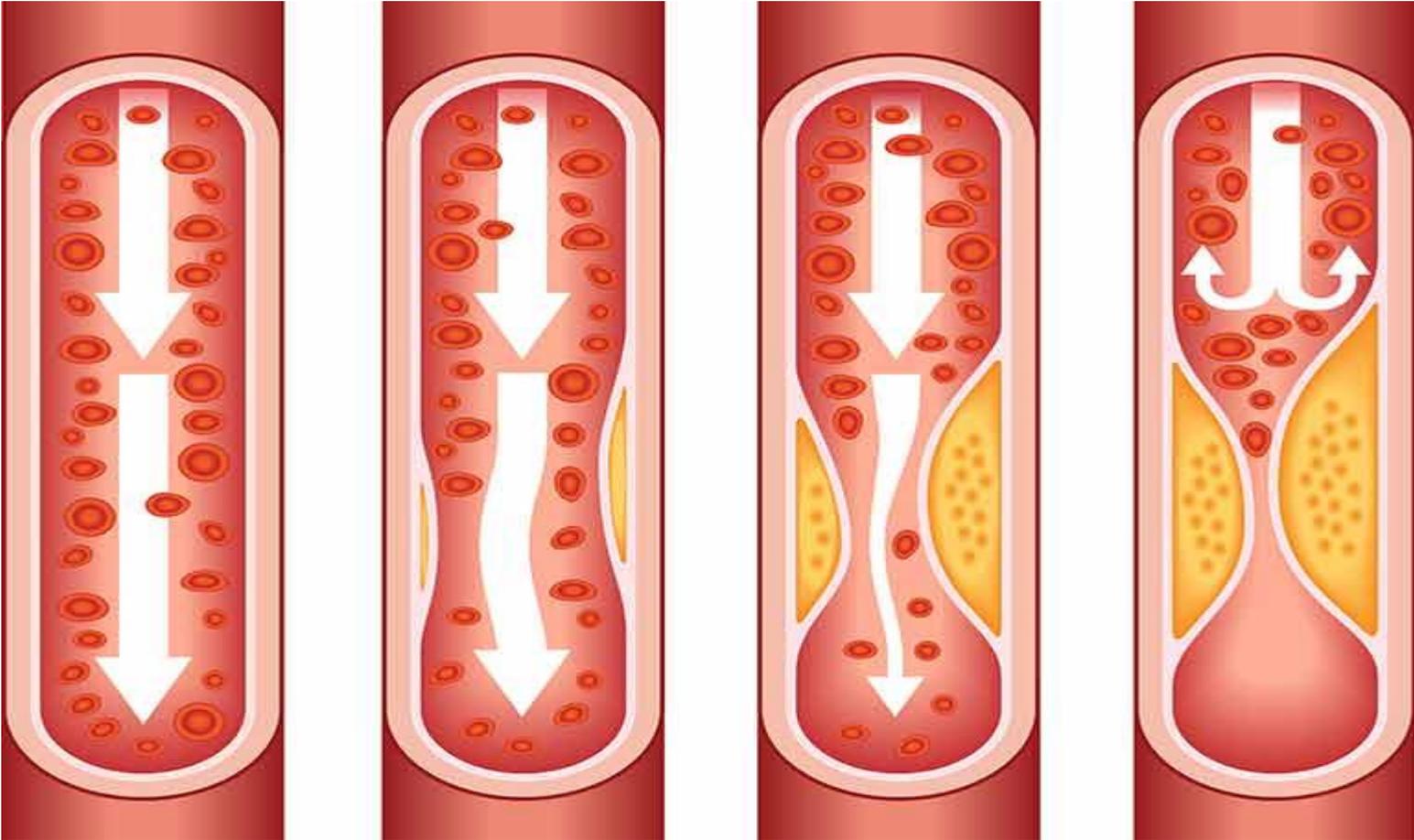
Measurement of Blood Pressure



CLINICAL FEATURES-COMPLICATIONS OF HYPERTENSION

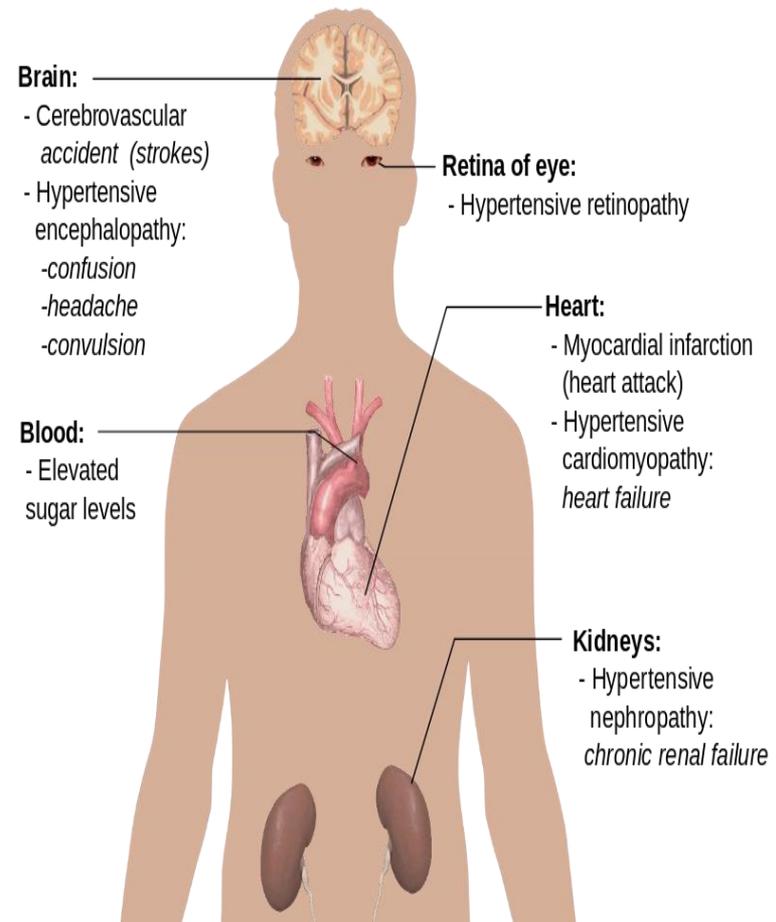


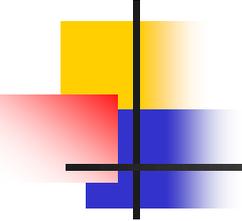
CLINICAL FEATURES-COMPLICATIONS OF HYPERTENSION



CLINICAL FEATURES-COMPLICATIONS OF HYPERTENSION

Headache
Nausea
Vomiting
Dizziness
Confusion
Shortness of breath
Chest discomfort
Visual disturbance
Sleepiness
May be asymptomatic





THANK YOU