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

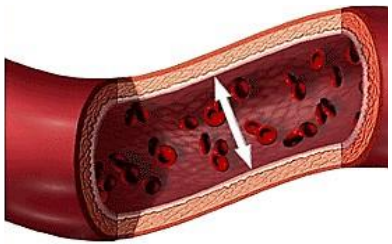
ARTERIAL BLOOD PRESSURE

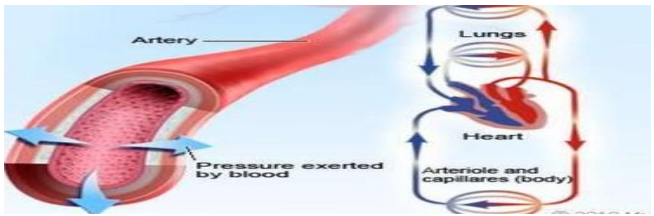
The pressure / force exerted by the blood against any unit area of the vessel wall is called Blood Pressure.

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)

1 ml of mercury pressure= 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.





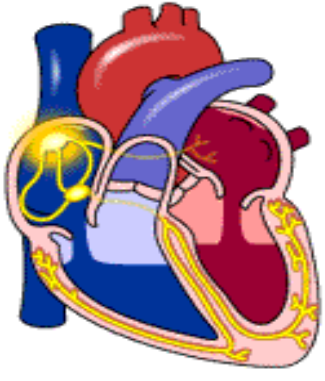
Guyton and Hall, pp 174

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

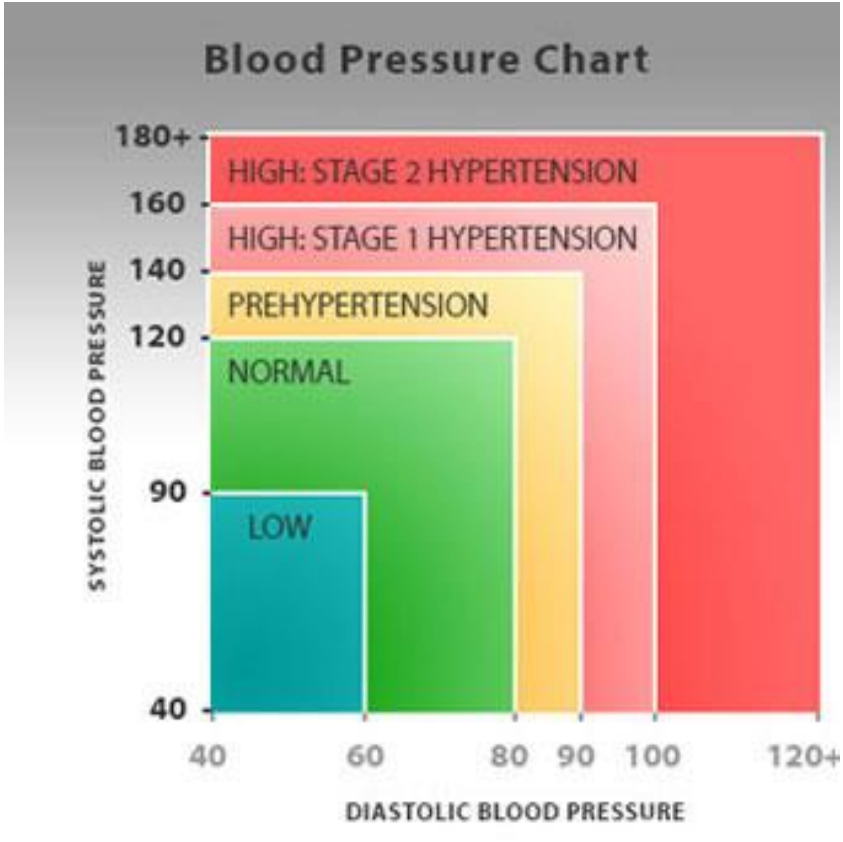
Average Normal Arterial Pressure:

80-120 mmHg systolic

60-80 mmHg diastolic

Guyton and Hall, pp 174

ARTERIAL BLOOD PRESSURE



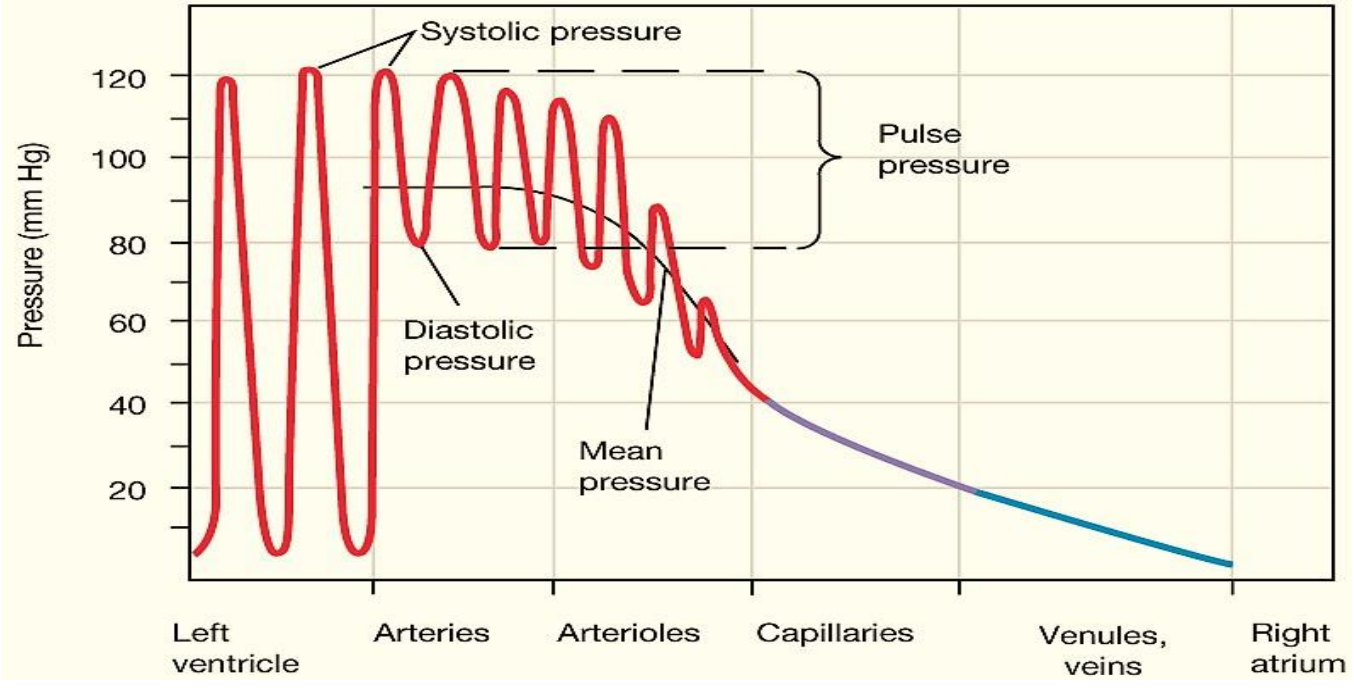
ARTERIAL BLOOD PRESSURE

Blood Pressure Categories

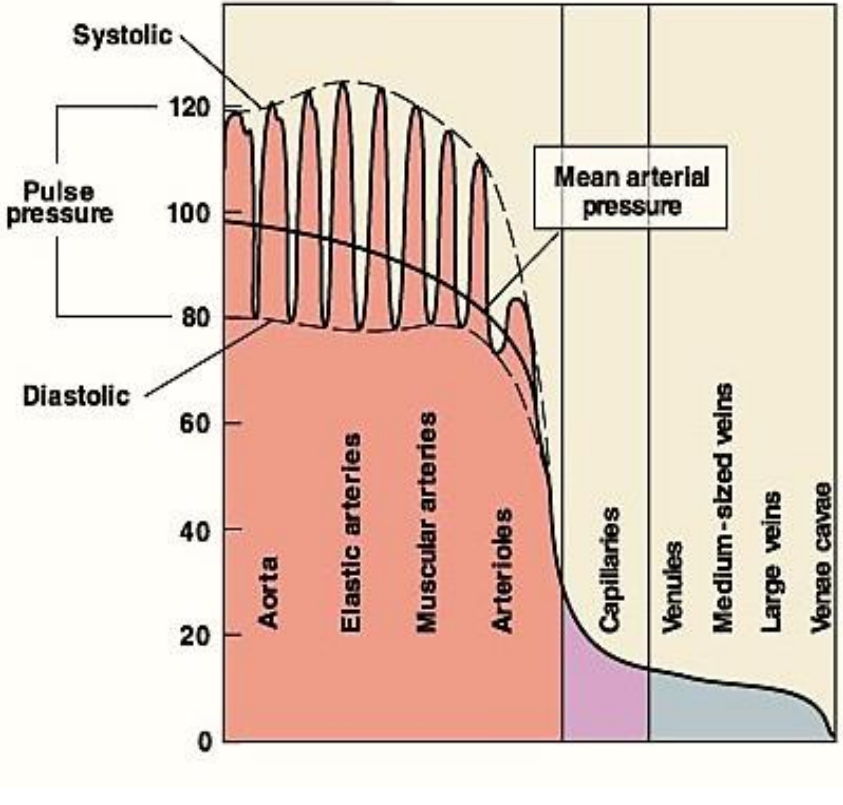
American Heart Association | American Stroke Association

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

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

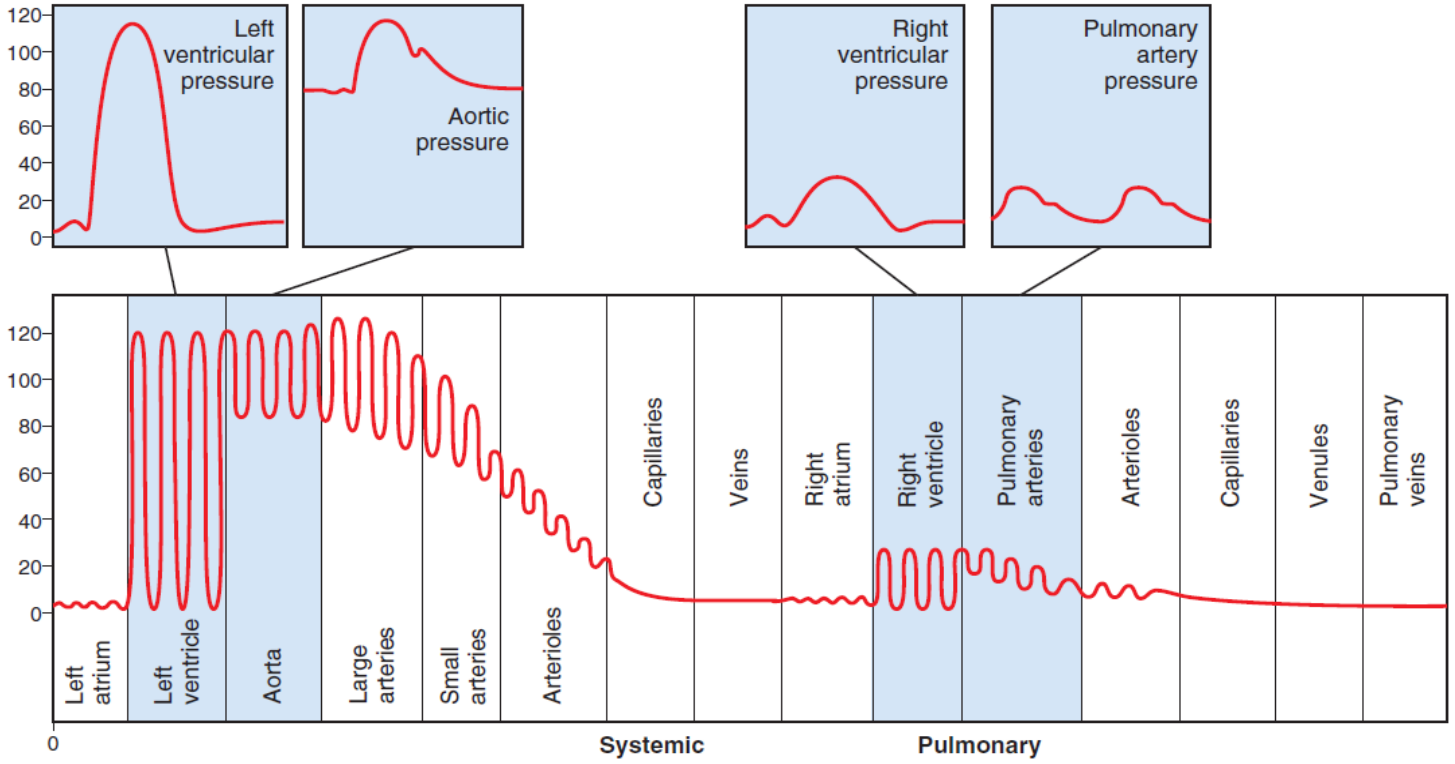
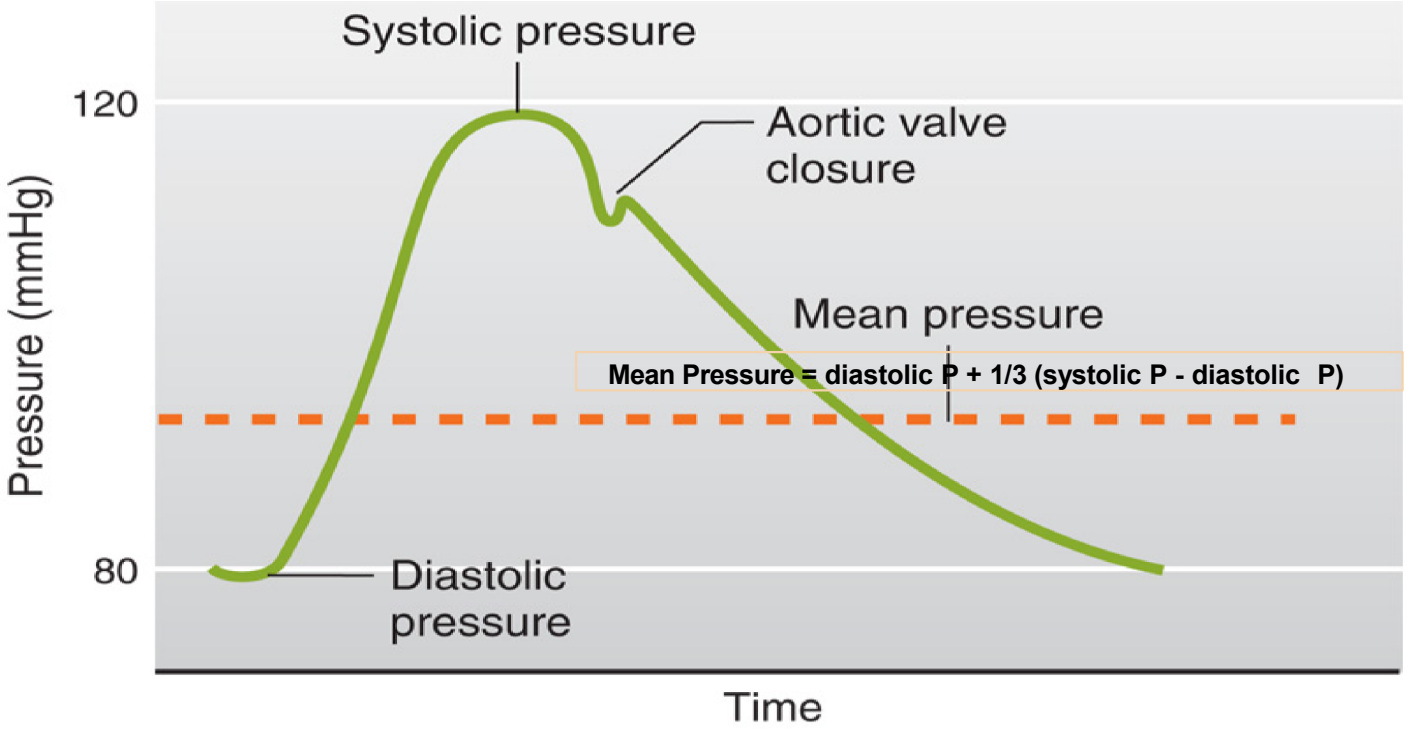


Figure 14-2. Normal blood pressures in the different portions of the circulatory system when a person is lying in the horizontal position.

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.

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

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

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

$$MAP = 61$$

Guyton and Hallm 183

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:

Mean Pressure = diastolic P + 1/3 (systolic P - diastolic P)

MAP = 1/3 (SBP – DBP) + DBP
MAP = 1/3 (83-50) + 50
MAP = 1/3 (33) + 50
MAP = 11 + 50
MAP = 61 mm Hg

PHYSIOLOGICAL FACTORS AFFECTING ARTERIAL BLOOD PRESSURE

- **Sex:** Male > Female … (equal at menopause)
- **Age:** (↑) Old age: Atherosclerosis

Sex: up to age of 40 years males have higher arterial values than women, becoming lower than women after age 50 (D'Alché 2008).

- **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

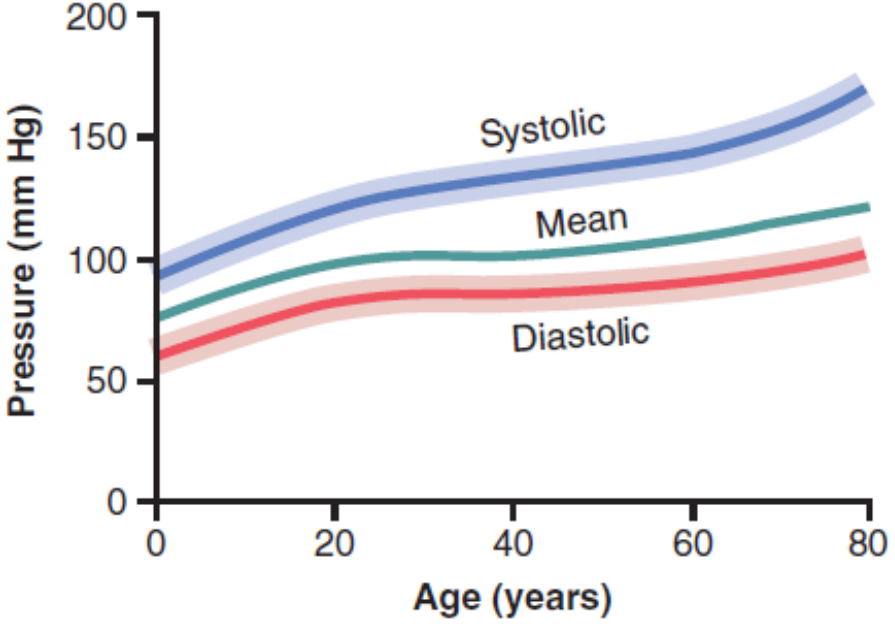
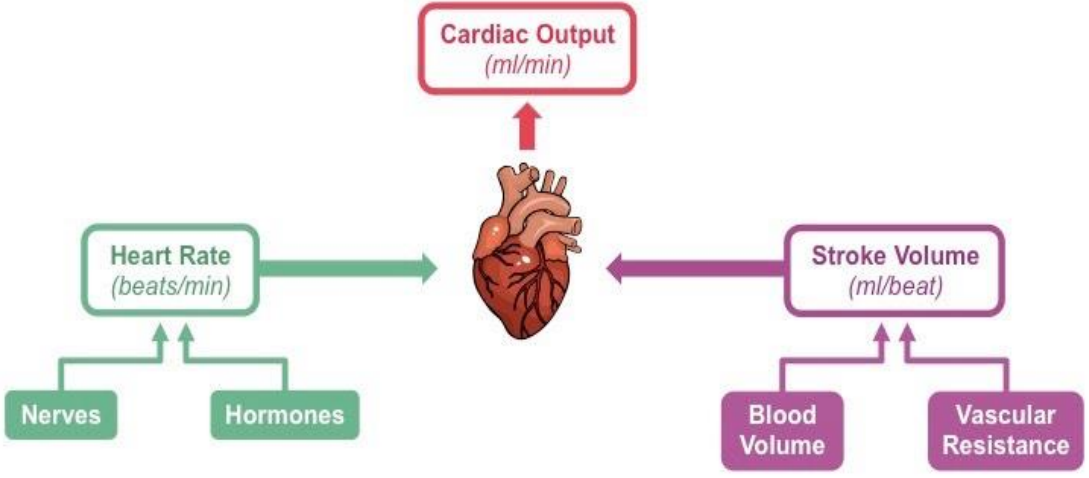
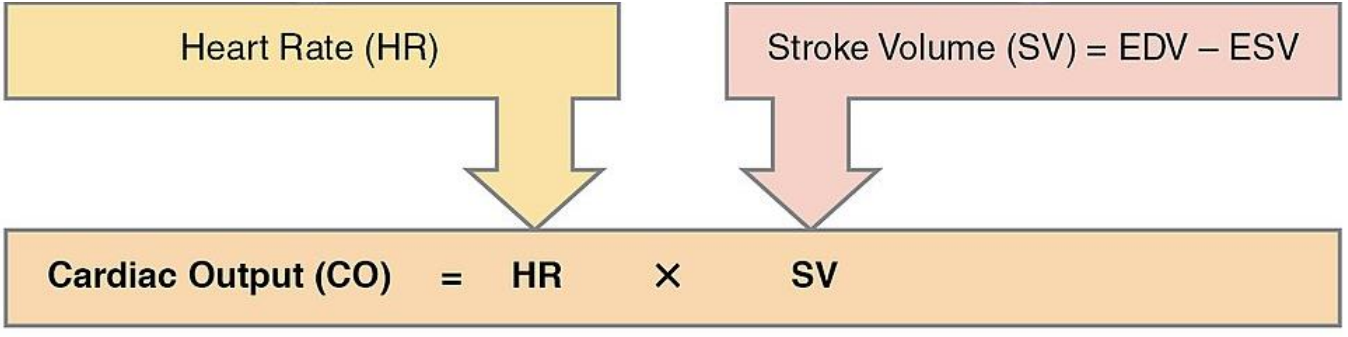


Figure 15-8. Changes in systolic, diastolic, and mean arterial pressures with age. The shaded areas show the approximate normal ranges.

Guyton and Hall, pp 183

PHYSIOLOGICAL FACTORS AFFECTING ARTERIAL BLOOD PRESSURE





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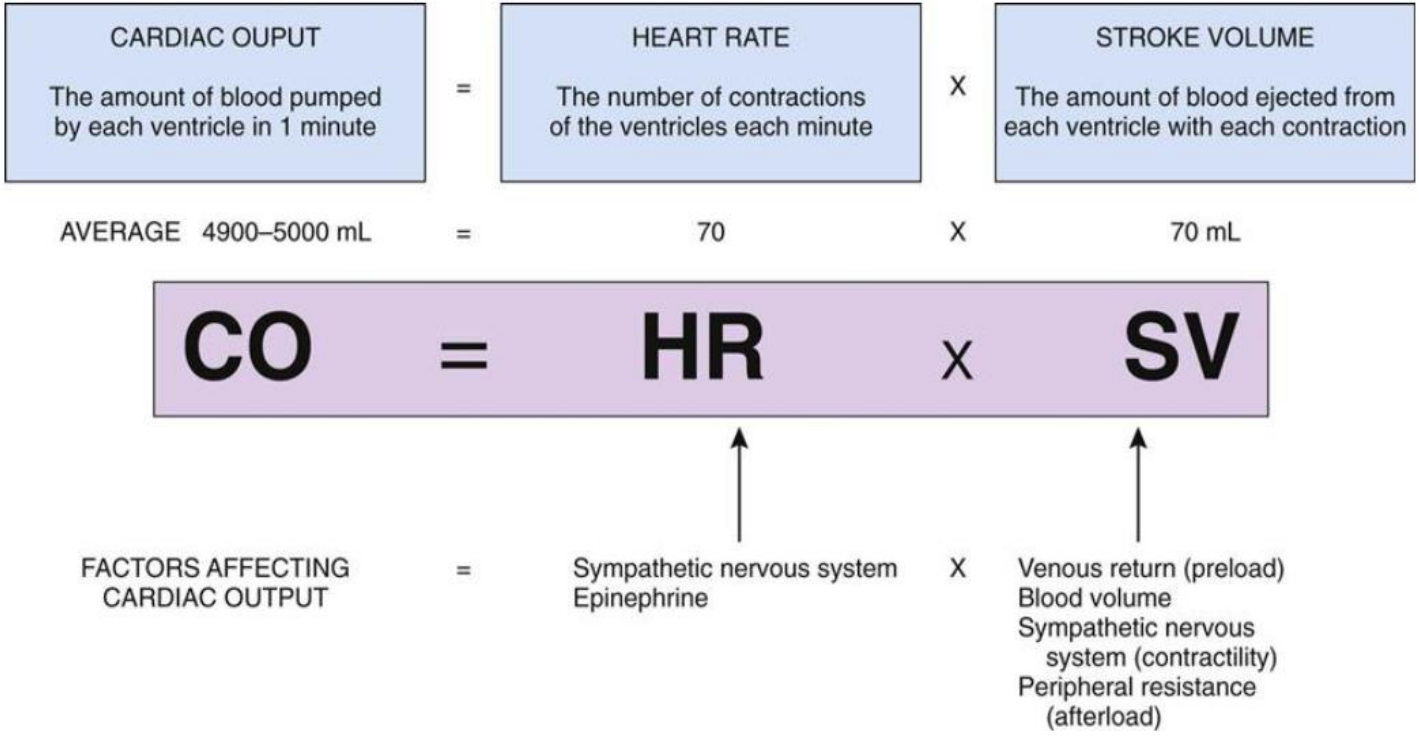

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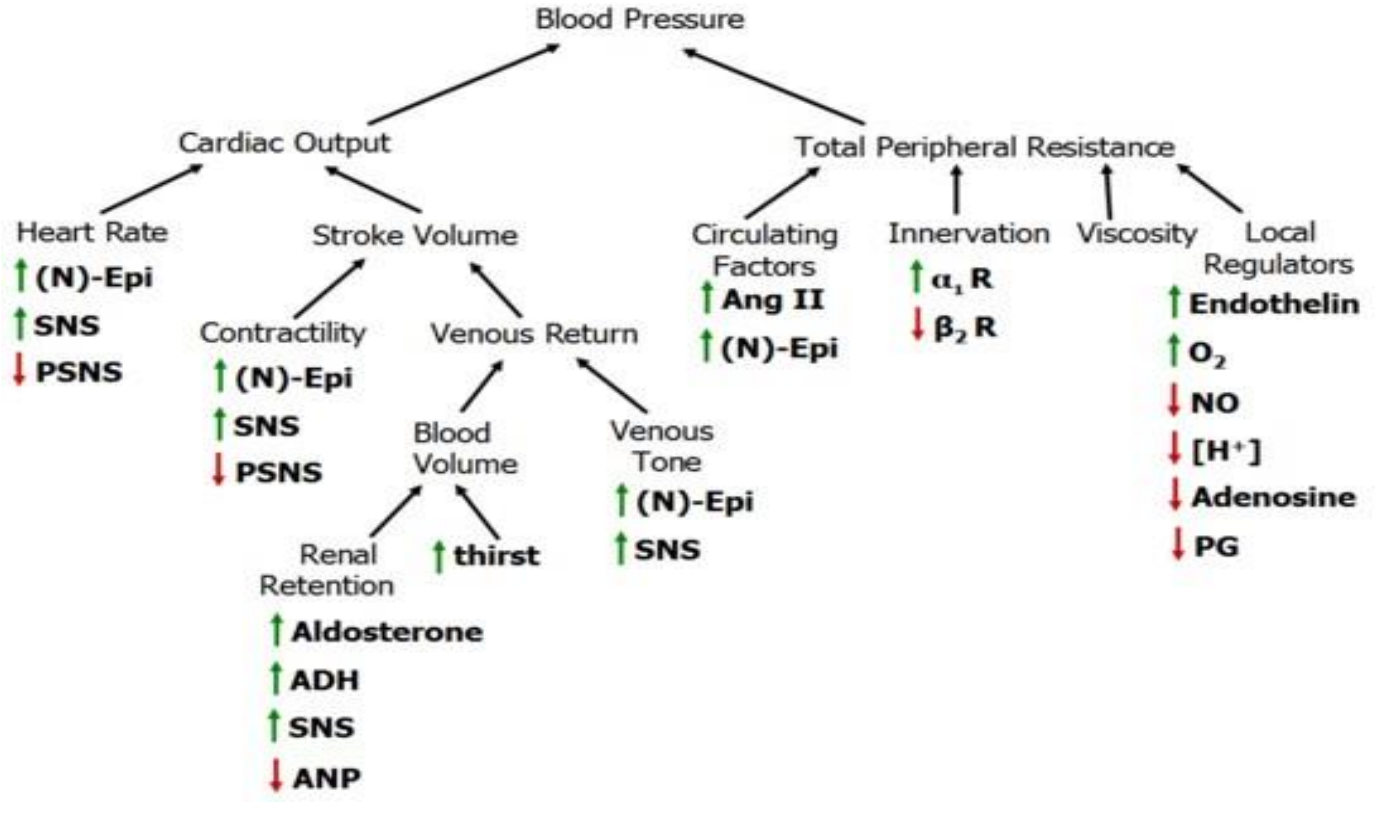


PHYSIOLOGICAL FACTORS AFFECTING ARTERIAL BLOOD PRESSURE

Factors determining CO:

1. Stroke volume
2. Heart rate

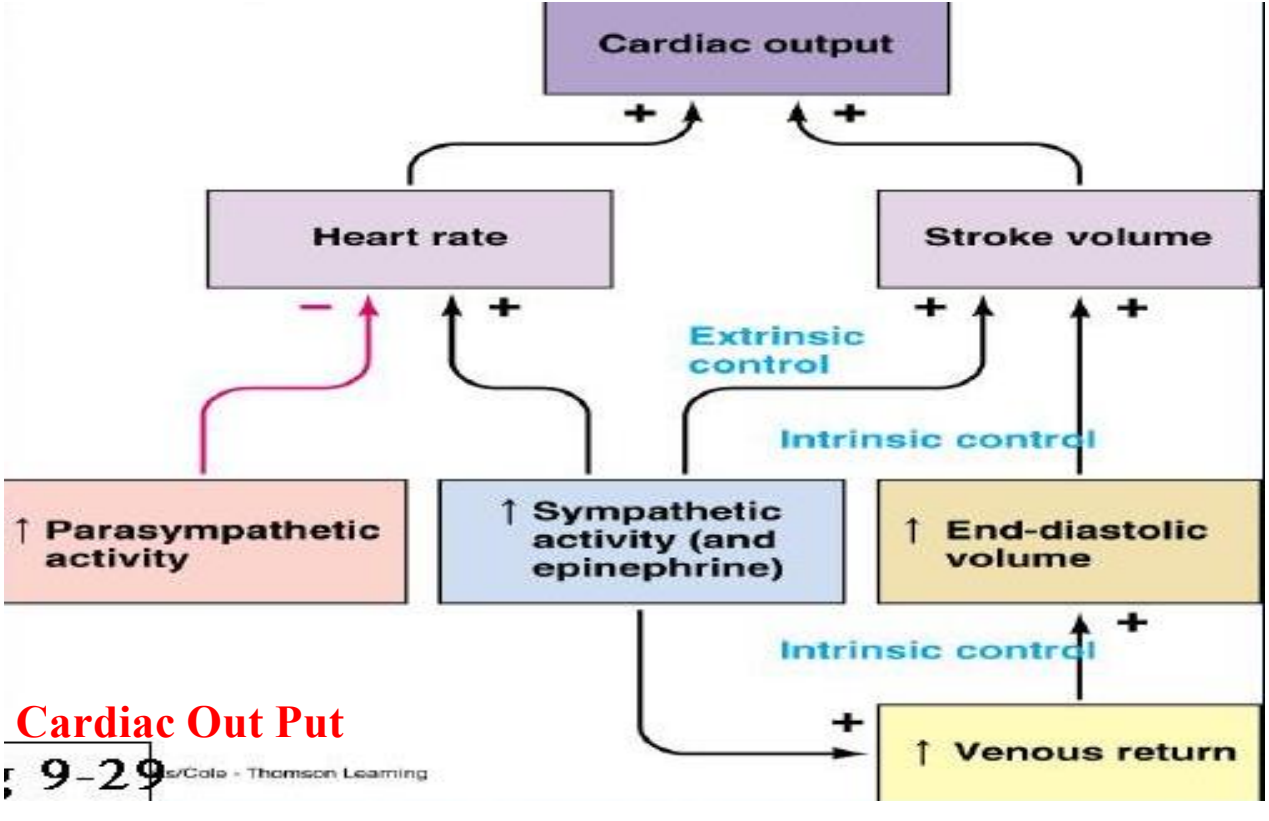
Cardiac Output (CO)

This is the amount of blood pumped by ventricles per minute

Cardiac Output = Stroke Volume X Heart Rate

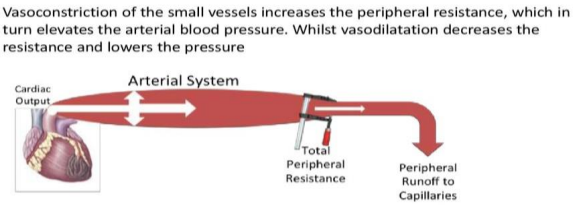
Cardiac Output (CO)	Stroke Volume (SV)	Heart Rate (HR)
= Output of ventricles / minute	= Output of ventricles / beat	= beats/ minute
≈ 5 L/min (av. 5-6 L/min)	70 ml/beat (av. 70-80 ml/beat)	≈ 70-75 beats/min (av 60-100 beats/min)

PHYSIOLOGICAL FACTORS AFFECTING ARTERIAL BLOOD PRESSURE



Total Peripheral Resistance (TPR)

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



Systemic Circulation:

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

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

$$TPR = 1.41$$

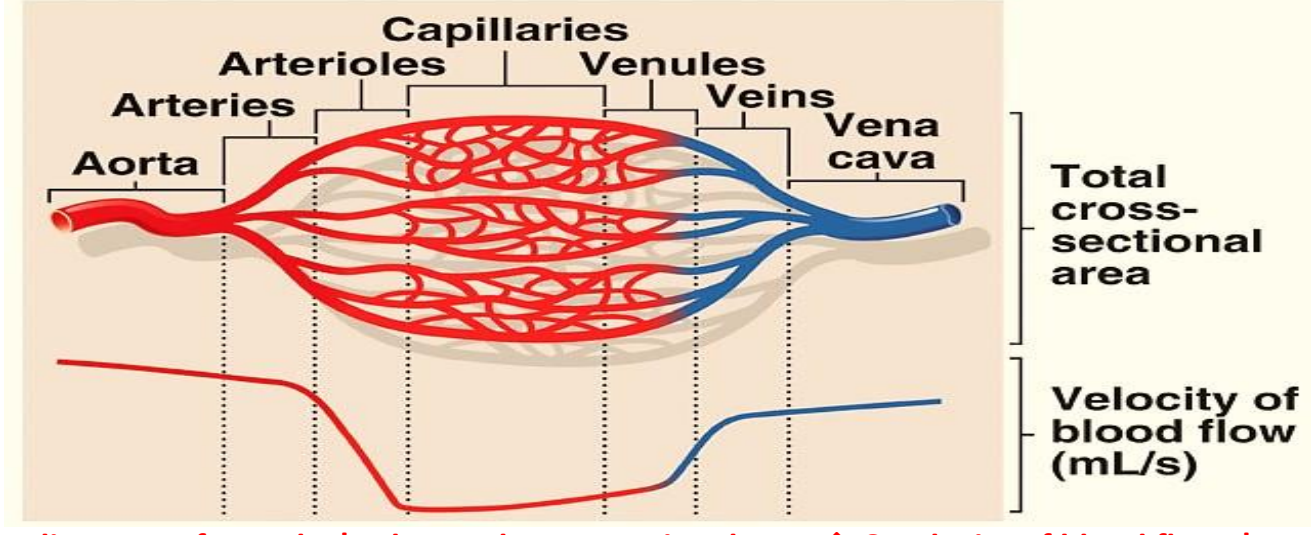
Pulmonary Circulation:

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

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

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

DIAMETER AND BLOOD FLOW

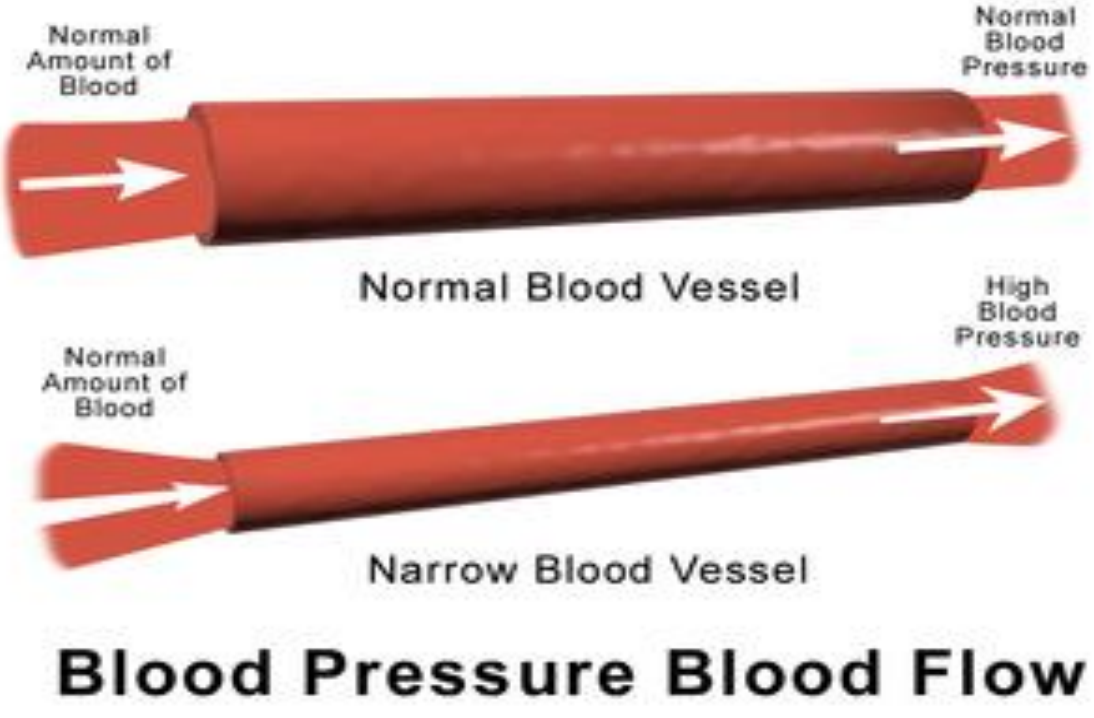


As diameter of vessels ↓, the total cross-sectional area ↑ & velocity of blood flow ↓

The velocity of blood flow within each segment of the circulatory system is inversely proportional to the total cross-sectional area of the segment. Because the aorta has the smallest total cross-sectional area of all circulatory segments, it has the highest velocity of blood flow.

The diameter of a single capillary is quite small, the number of capillaries supplied by a single arteriole is so great that the total cross-sectional area available for the flow of blood is increased. Hence, the pressure of the blood as it enters the capillaries decreases.

Effect of Radius on Pressure



BLOOD PRESSURE AND BLOOD VOLUME

Blood Volume:

An increase in blood volume → ↑CO → ↑ABP.

A decrease in blood volume as in hemorrhage, dehydration → ↓VR → ↓CO → ↓ 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 → ↑ PP.

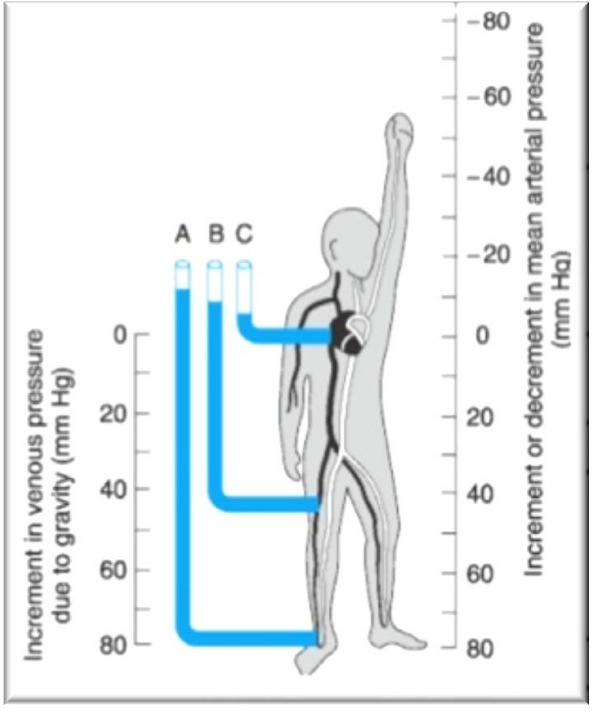
Effect of Gravity on Blood Pressure

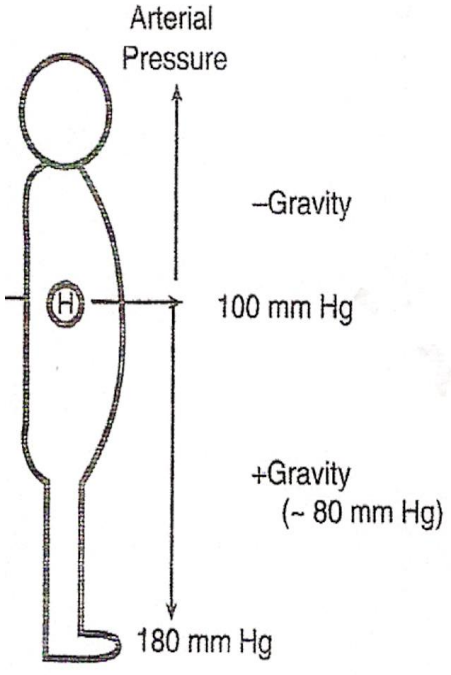
The pressure in any vessel below the level of the heart is increased

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-[0.77X 50] = 62 mmHg.





Above heart level

50cm = 100 – [0.77 X 50] = 62 mm of Hg

1cm = 0.77 mm of Hg

Below heart level

105cm = 100 + [0.77 X 105] = 180 mm of Hg

Factors affecting vessel diameter

- Vasodilator agents:
  - Nitric oxide.
  - Histamine.
  - Atrial natriuretic peptide (ANP).
  - Prostacyclin; PGI_2.
- Vasoconstrictor agents:
  - Norepinephrine.
  - Angiotensin II.
  - Vasopressin.
  - Endothelin-1.
  - Thromboxane A_2.

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

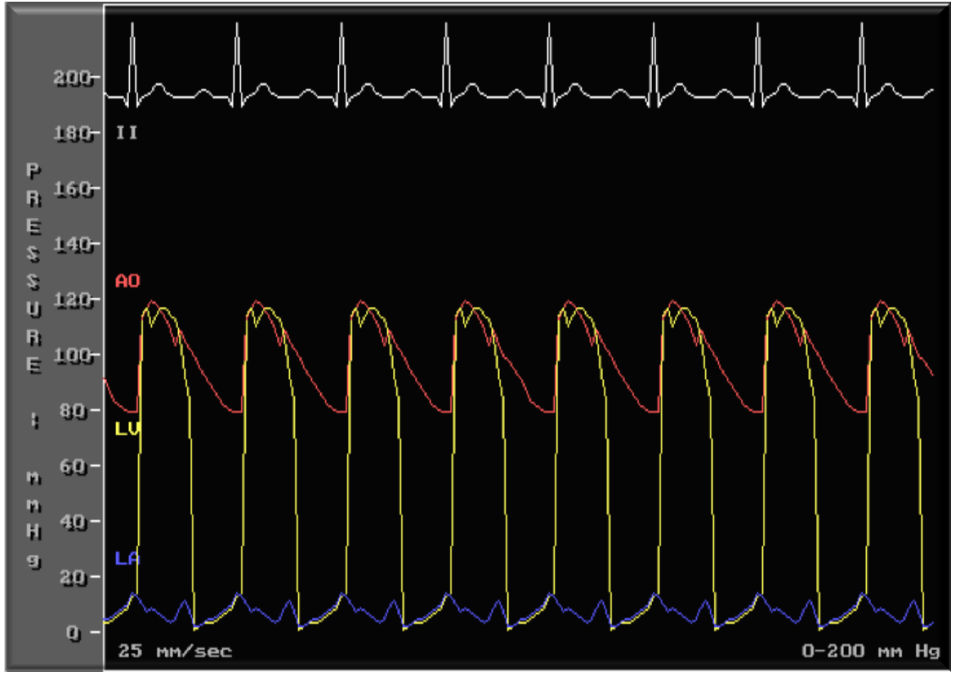
Measurement of Blood Pressure

Direct

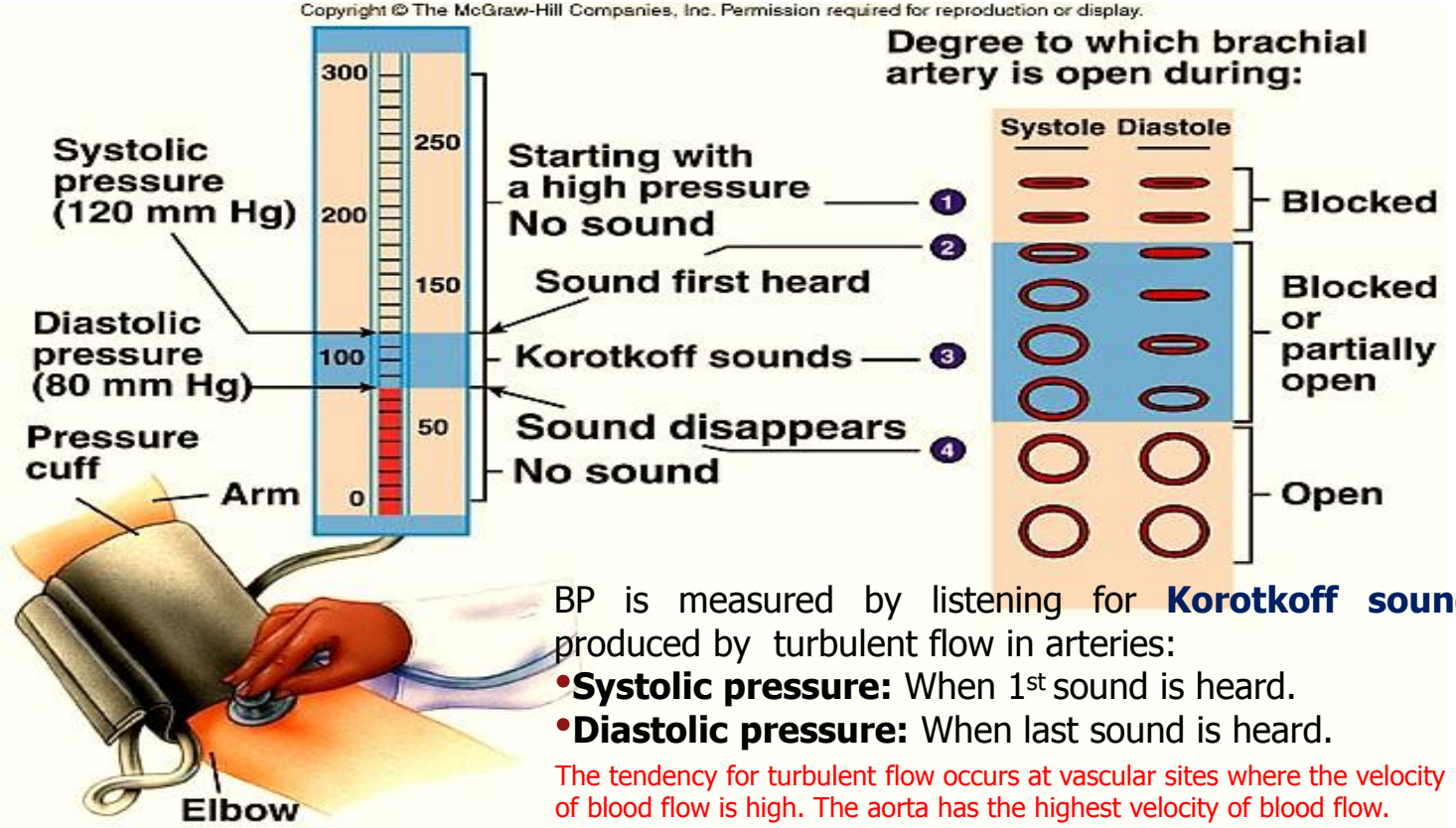
Arterial catheter

Indirect

Stethoscope and blood pressure cuff



Measurement of Blood Pressure

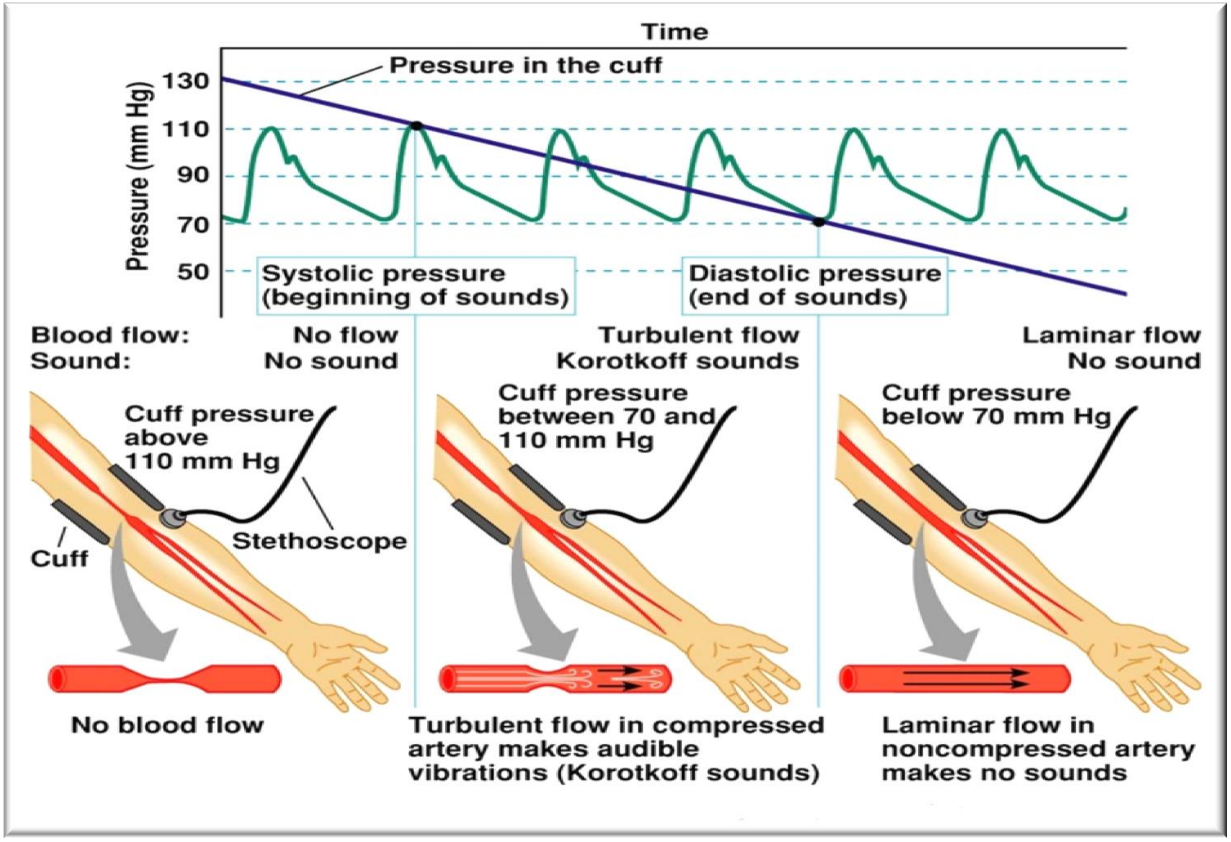


BP is measured by listening for **Korotkoff sounds** produced by turbulent flow in arteries:

- **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



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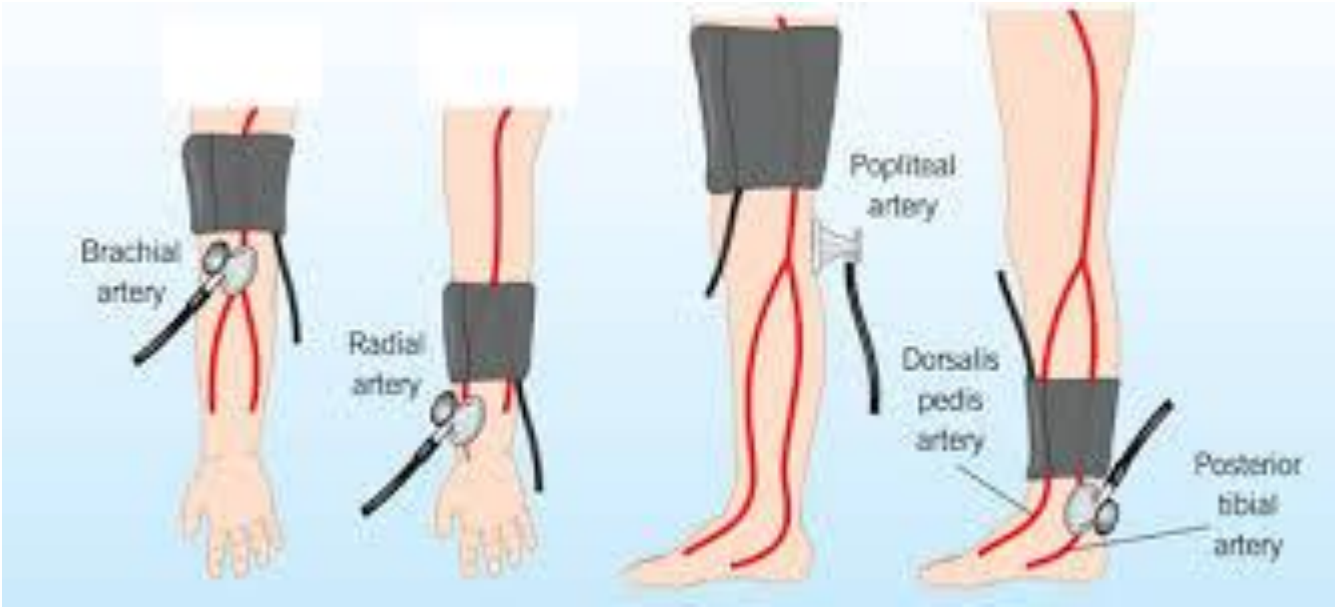
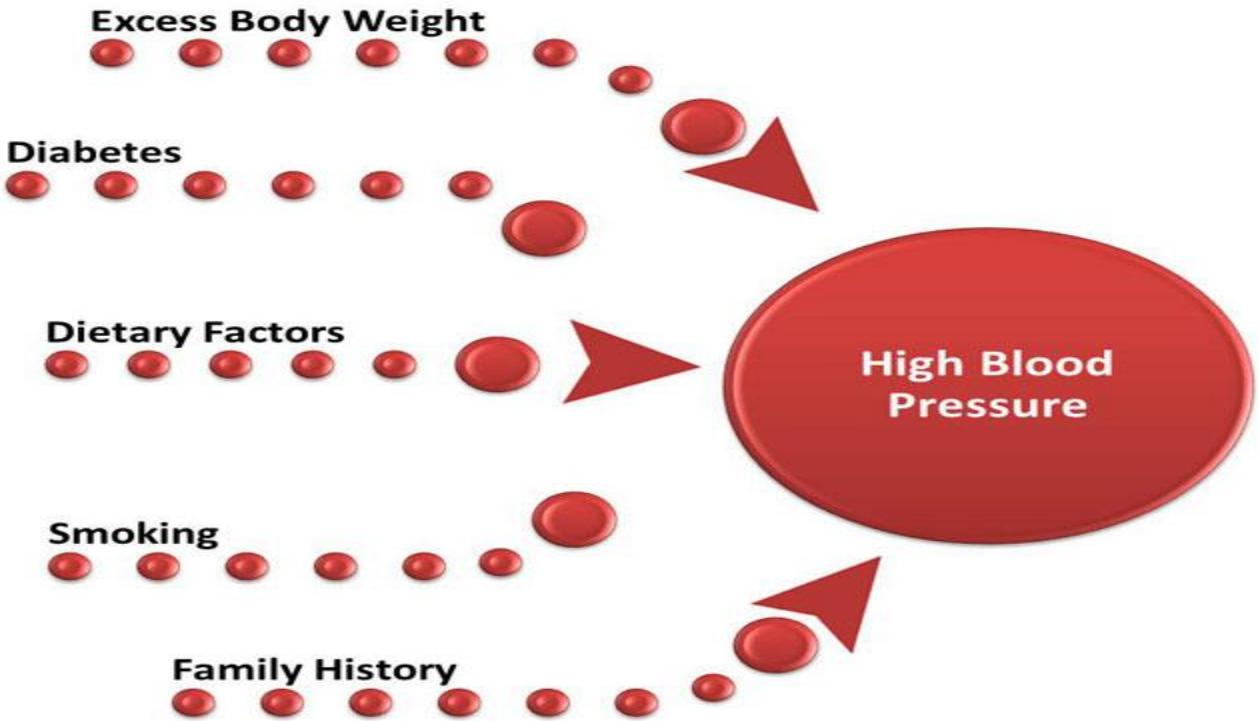


CLINICAL FEATURES-COMPLICATIONS OF HYPERTENSION



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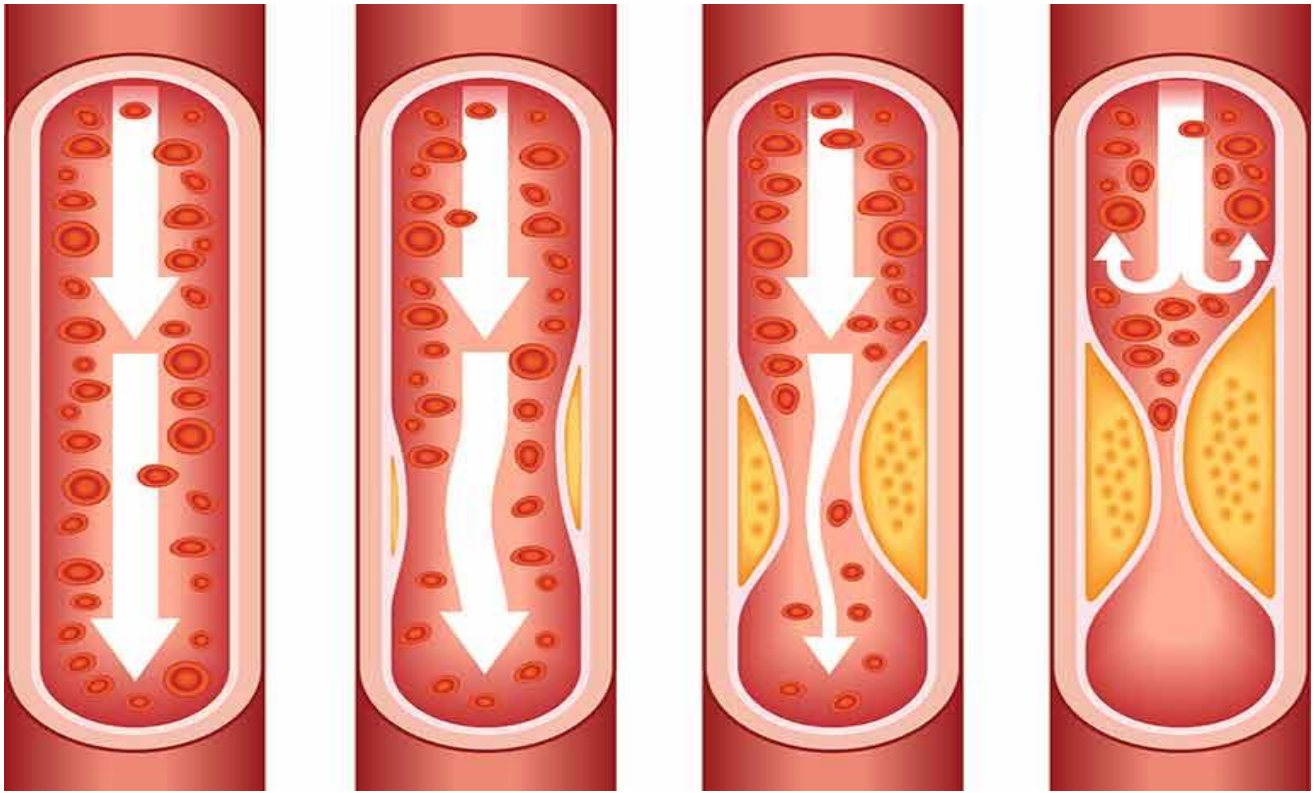
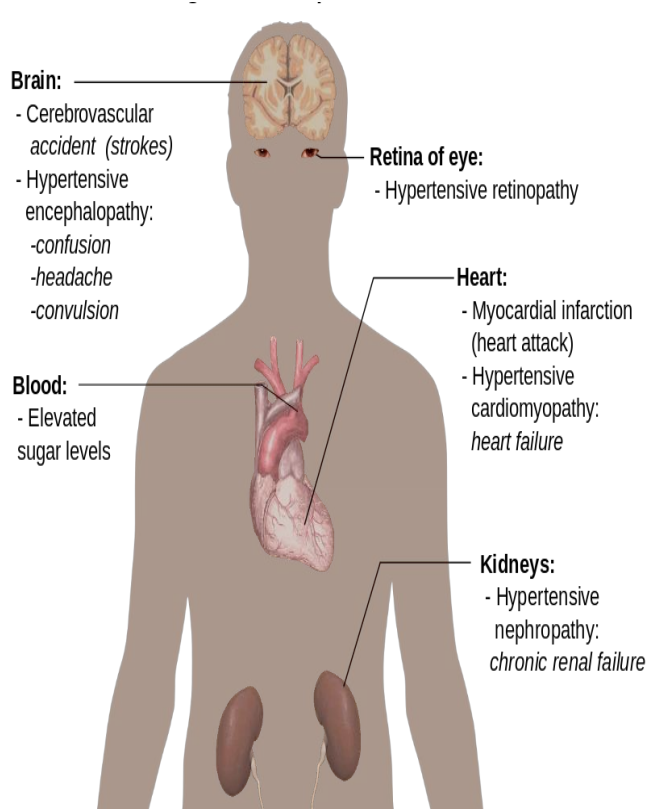


CLINICAL FEATURES-COMPLICATIONS OF HYPERTENSION

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



THANK YOU