Arterial Blood Pressure

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2025-2026

- **Definitions:**

Arterial blood pressure (ABP): it is the lateral pressure of the blood on the arterial wall.

The systolic blood pressure: the maximum pressure that reached during ventricular systole ranges from 90 - 140 mmHg with average 120 mmHg.

The diastolic blood pressure: the minimal pressure that reached just before the ventricular contraction ranges from 60 - 90 mmHg with an average value of 80 mmHg.

Cause of arterial blood pressure:

The systolic blood pressure is caused by ejection of the blood during the systole where:

- Only 1/3 stroke volume leaves the arteries
- 2/3 stroke volume distends the arteries and elevates the blood pressure up to 120 mmHg.

- **After the systole,** the BP begins to decrease but the elastic recoil elevates the pressure to drive the blood through the peripheral circulation.

- Thus the elastic recoil acts as a pump that keeps the diastolic pressure from excessive decrease.

- The diastolic pressure decreases then when it reaches 80 mmHg the next ventricular systole raising the pressure again to its systolic value.

- **Pulse pressure:**

- It is the difference between the systolic and diastolic blood pressure i.e.

pulse pressure = systolic BP - diastolic BP

= 120 - 80 = 40 mmHg

- It increased in cases of hyperdynamic circulation as:

Aortic regurgitation, Arteriosclerosis , Sever anemia, Hyperthyroidism and Pregnancy.

- It decreased in hemorrhage

- **Mean systemic arterial blood pressure:**

- It is the average pressure in the systemic arteries throughout the cardiac cycle.

Mean systemic ABP = diastolic P + 1/3 PP

= 80 + 1/3 (40) = 93 mmHg

- **Importance:**

It represents the force that drives the blood to the tissues

Importance (function) of the arterial blood pressure

(1) It maintains tissue perfusion (i.e. blood flow) throughout various tissues, including those lying above the heart level (in spite of the force of gravity)

(2) It produces the capillary hydrostatic pressure, which is the main force concerned with tissue fluid formation.

(3)The diastolic B.P. performs the following functions:

a- It maintains blood flow to the tissues during ventricular diastole (thus the blood flow to the tissues becomes continuous and not intermittent)

b- It is essential for the normal coronary blood flow

c-It prevents blood stasis in the arteries during ventricular diastole (by keeping the blood flow). This reduces the energy required for the cardiac pump function.

PHYSIOLOGICAL VARIATION OF ABP

1. Age

- In newly - born infants the blood pressure is 80/40

- Then it increases gradually where
  - at 4 years old it is 100/65
  - at 20 years it is 120/80

- It increases gradually after the age of 20 years to reach 150/90 at the age of 60 years due to decrease the elasticity of arteries.

2. Sex

The blood pressure in adult male is higher than in adult female

After the menopause it becomes higher in females (withdrawal of female sex hormones)

3. Body built

The blood pressure usually higher in obese persons.

4. Race

The blood pressure in Orientals is less than that in Europeans and Americans may be due to:

(a) Genetic factors
(b) Environmental factors
(c) Low cholesterol in diet
(d) Less stress in life.

5. Sleep

During quiet sleep the ABP is decreased due to parasympathetic activity

6. Emotions

In different emotional state (e.g. anger) the ABP is elevated due to sympathetic over activity

7. Meals

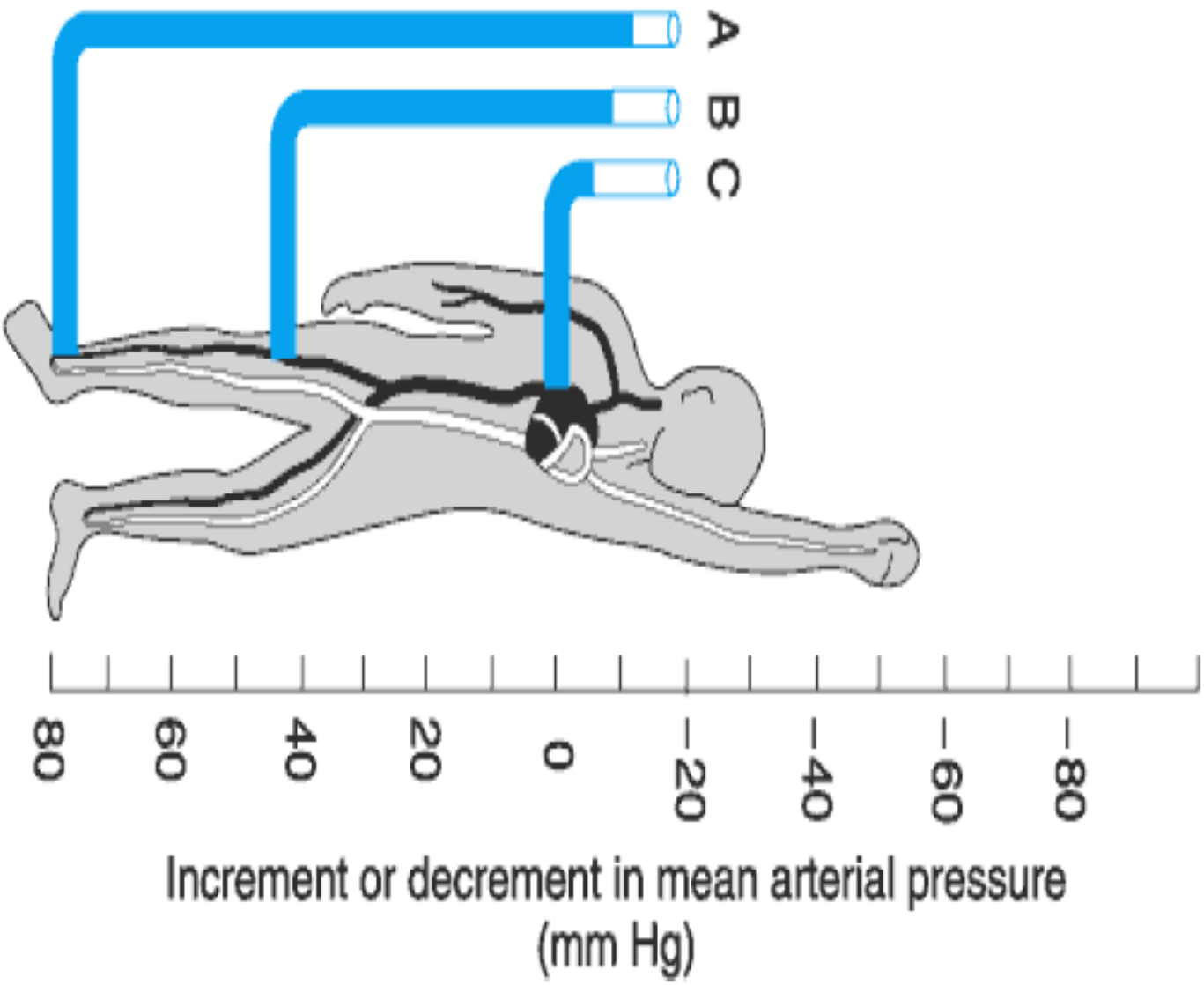
After meals the ABP increases due to

(a) The contraction of smooth muscles of the gut compress the blood vessels thus increasing VR and COP

(b) The VD occurring in the splanchnic area increases the VR and also COP

8. Gravity

- During standing, the BP increases in all vessels below the heart and decreases in vessels above the heart level.
- The rise or decrease in BP is equal to the weight of blood column from the vessel to the heart i.e. 0.77 mmHg per cm.


A
B
C
80
60
40
20
0
−20
−40
−60
−80
Increment or decrement in mean arterial pressure
(mm Hg)

9. Exercise

In the isometric (static exercise):

SBP and DBP rise sharply and return immediately to normal after stoppage of exercise. This is due to reflex action by impulses originate in the contracting muscles proprioceptors to stimulate VMC.

- In the isotonic (dynamic exercise): The SBP increases sharply, while the DBP remains constant or even decreases and this effect remains for a time after exercise due to VD of the skeletal muscle vessels resulting from accumulation of vasodilator metabolites.

10. Respiration: (Respiratory pressure waves)

- The changes in the BP during each respiratory cycle are called "respiratory pressure waves".

- "The ABP increases during the late part of inspiration and the early part of expiration, while it falls during the remainder of the respiratory cycle".

Mechanism:

1. Early part of inspiration:

The dilatation of the chest and the increased intrathoracic negativity cause the pulmonary vascular bed to dilate thus the blood return to left ventricle is decreased → decrease COP and ABP

2. Late part of inspiration:

Due to the increase in the venous return to the left side of the heart → ↑ COP → ↑ ABP, and the active inspiratory center sends excitatory impulses to VMC → V.C. → ↑ ABP

3. The early part of expiration:

Narrowing of the chest walls compresses the pulmonary blood vessels → increase the volume of the blood returning to left ventricle → increase COP and ABP

4. The late part of expiration:

The blood pressure decreases as a result of decrease VR, the cause of decreased VR is increased chest pressure

Factors that determine and maintain the arterial blood pressure:

$$\text{Flow} = \frac{\text{Pressure gradient}}{\text{resistance}}$$

$$\text{COP} = \frac{\text{Arterial blood presure - central venous P}}{\text{total peripheral resistance}}$$

$$\text{COP} = \frac{\text{ABP} - \text{CVP}}{\text{TPR}} = \frac{\text{ABP} - \text{O}}{\text{TPR}}$$

ABP = COP x TPR= SV x HR x TPR

Arterial blood pressure =

heart rate X stroke volume X peripheral resistance

From this equation

the factors that determine the arterial blood pressure are:

1. Stroke volume:

- Provided that heart rate is constant the SV affects both the systolic BP and diastolic BP but the effect on the systolic BP is more → increase pulse pressure.
- The cardiac contractility determines the Stroke volume

2. Heart rate:

- When the SV remains constant, the changes in the heart rate affect mainly the diastolic BP while the systolic BP remains almost constant → decrease pulse pressure.

3. Total peripheral resistance (TPR):

- It is the resistance that opposes the blood flow, it is present mainly in the arterioles.
- It elevates the diastolic pressure more than the systolic pressure → the pulse pressure is decreased.

Two factors determine the PR

(a) Arteriolar diameter

- The PR increases with the decrease of the arteriolar diameter i.e.
- V.C. → decrease in arteriolar diameter → increase in peripheral resistance and the blood pressure increases.
- V.D. → increase in arteriolar diameter → decrease in PR → decrease in the blood pressure (particularly the diastolic).

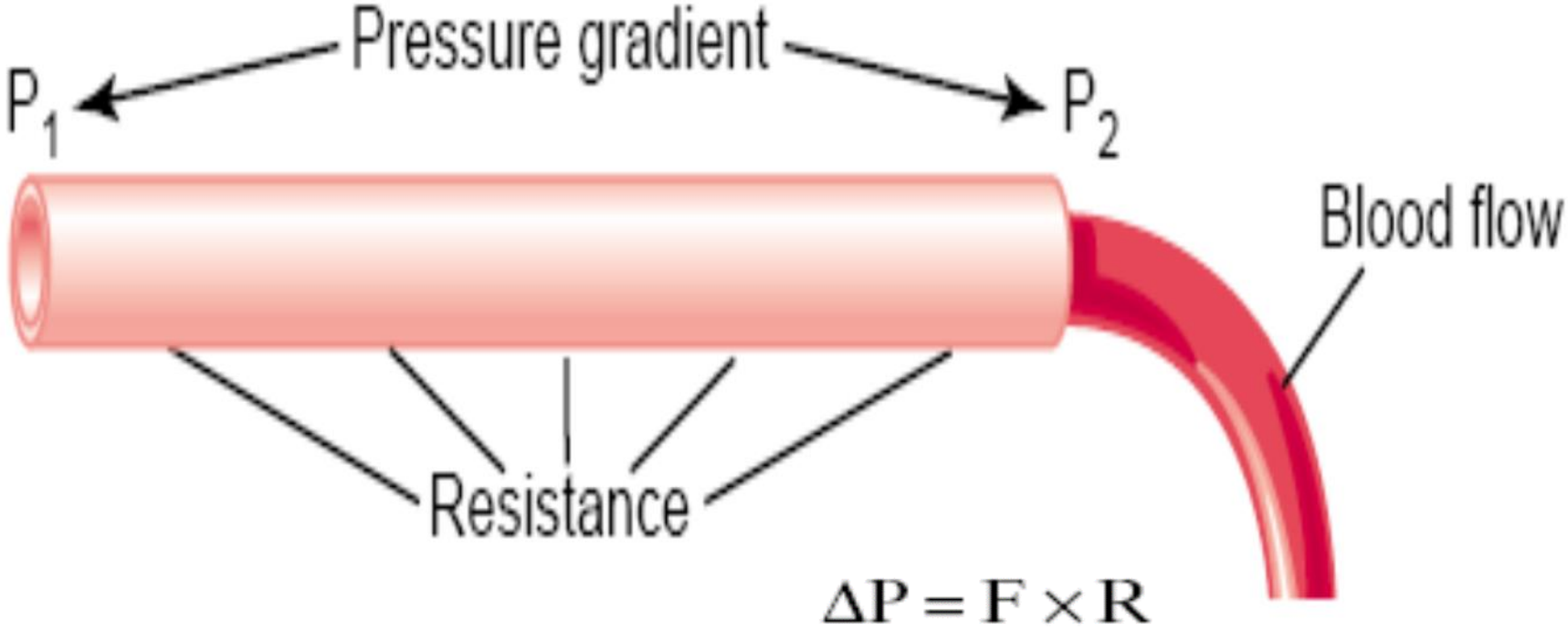
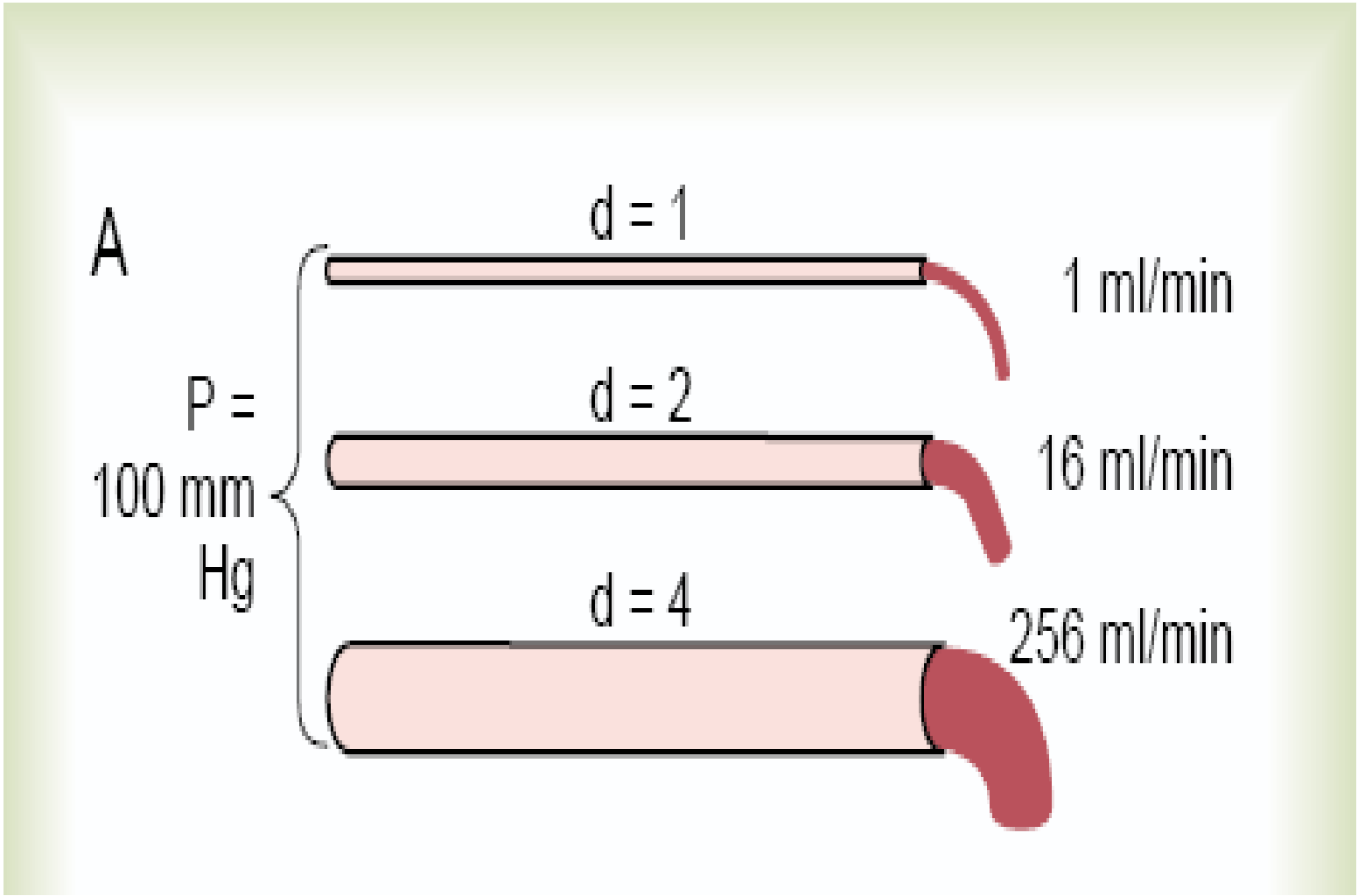


Figure 14–3

Interrelationships among pressure, resistance, and blood flow.

Poiseuille's Law ; Fourth Power Law

$$F = \frac{\pi \Delta P r^4}{8 \eta l}$$


A
d = 1
1 ml/min
P =
100 mm
Hg
d = 2
16 ml/min
d = 4
256 ml/min

(b) The blood viscosity:

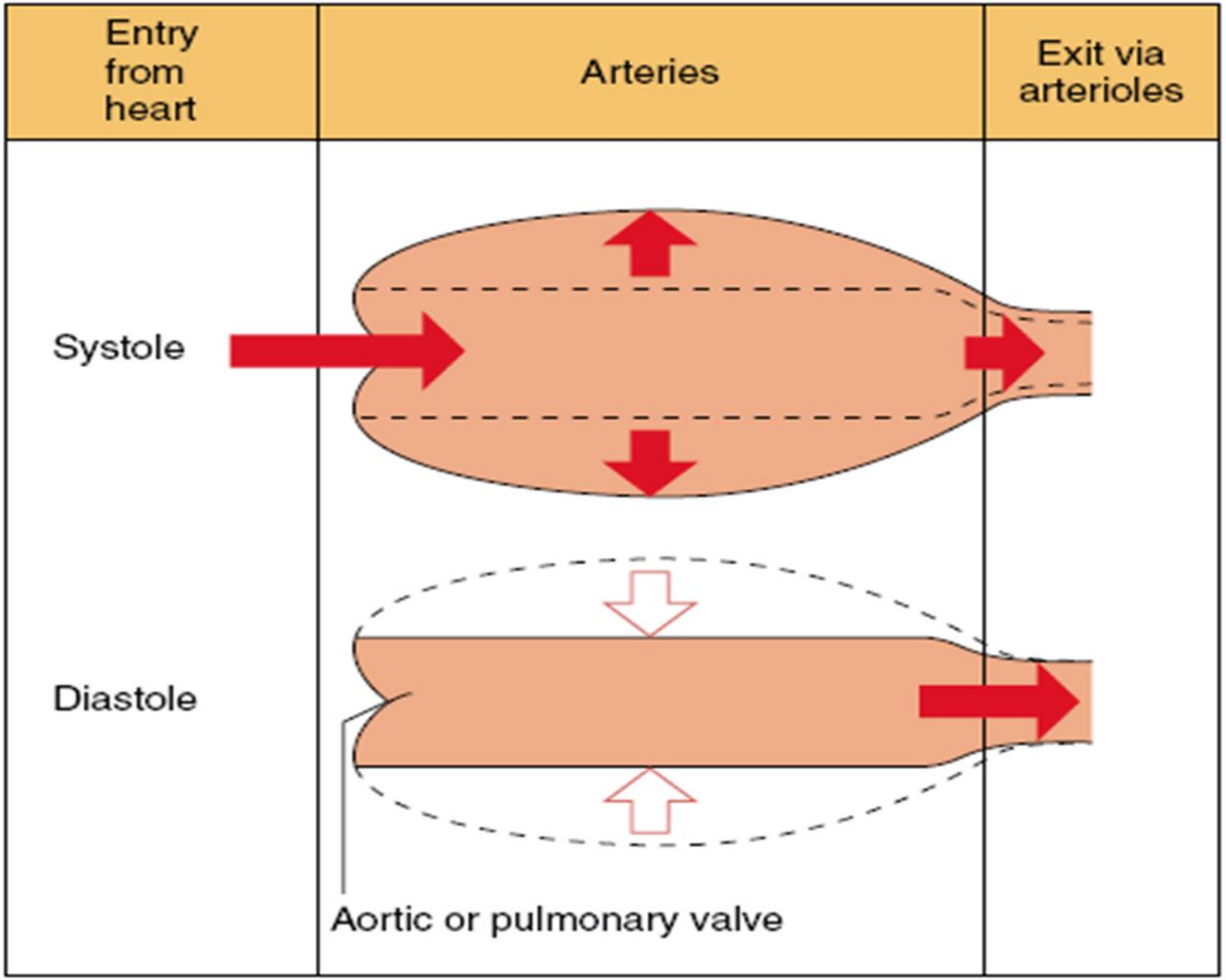
- **The PR directly proportional to the blood viscosity which is determined by the hematocrit value (e.g. hypoxia → stimulation of RBCs production → ↑ hematocrit value → ↑ PR → ↑ BP particularly the diastolic and this in turn decreases the pulse pressure.**

  The main factor affecting the peripheral resistance and the diastolic pressure is the diameter of the arterioles.

4. **Elasticity:** Importance of elasticity of aorta and arteries

(a) It prevent excessive elevation of the systolic pressure where 2/3 SV stretch the aorta while 1/3 SV leave it i.e. if the ability of the arteries to be stretched is lost by atherosclerosis the systolic pressure will be sharply high.

(b) The elastic recoil is important for maintaining the diastolic blood pressure thus atherosclerosis of aorta and arteries leads to excessive decrease in the diastolic pressure.


Entry from heart
Arteries
Exit via arterioles
Systole
Diastole
Aortic or pulmonary valve

Atherosclerosis of arteries elevates

the SBP while decreases the DBP

leading to increasing in the Pulse Pressure

5. The blood volume and circulatory capacity:

Changing of both blood volume and circulatory capacity affect VR and COP. Thus they determine the arterial pressure particularly the systolic blood pressure.


THANK
YOU