Cardiovascular Physiology
Mean Arterial Blood Pressure
Fall 2019-2020

Part 13-14

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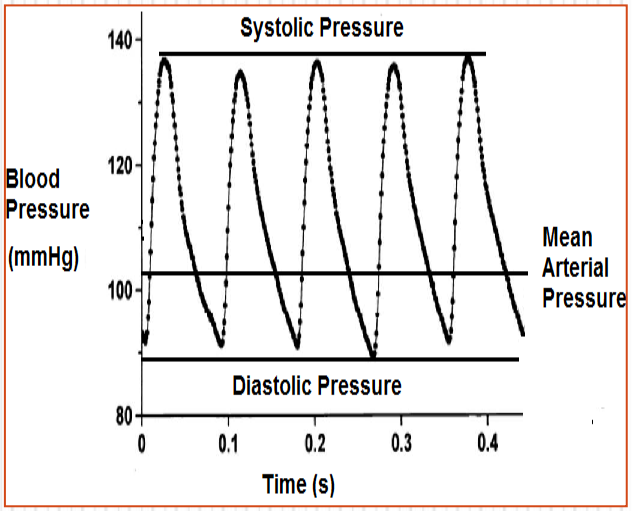


Outline

- Systolic BP and diastolic BP.
- Pulse pressure and mean ABP.
- Physiological variations of ABP.
- Factors that maintain normal ABP:
  - ✓ Cardiac output (CO)
  - ✓ Peripheral Vascular Resistance (PVR)
  - ✓ Arterial elasticity
  - ✓ Blood volume

Arterial Blood Pressure

- **Arterial Blood Pressure (ABP)** is the lateral pressure exerted by the blood on the arterial walls. It oscillates during each cardiac cycle between a maximum called systolic BP and a minimum called diastolic BP.

- **Systolic BP:**
  - ✓ It is the maximal pressure exerted by the blood on the arterial walls during ventricular systole (ejection of blood from the left ventricle into the aorta).
  - ✓ It ranges between 95 and 145 mm Hg with an average of about 120 mm Hg in adults i.e. normal systolic BP=120 ± 25 mm Hg.

- **Diastolic BP:**
  - ✓ It is the minimal pressure exerted by the blood on the arterial walls during ventricular diastole (just before ventricular systole and ejection of blood).
  - ✓ i.e. normal diastolic BP=80 mm Hg.

Arterial Blood Pressure

- **Pulse pressure:**

✓ It is the difference between systolic blood pressure and diastolic blood pressure e.g. *PP=120-80 = 40 mm Hg.*

- **Mean Arterial BP:**

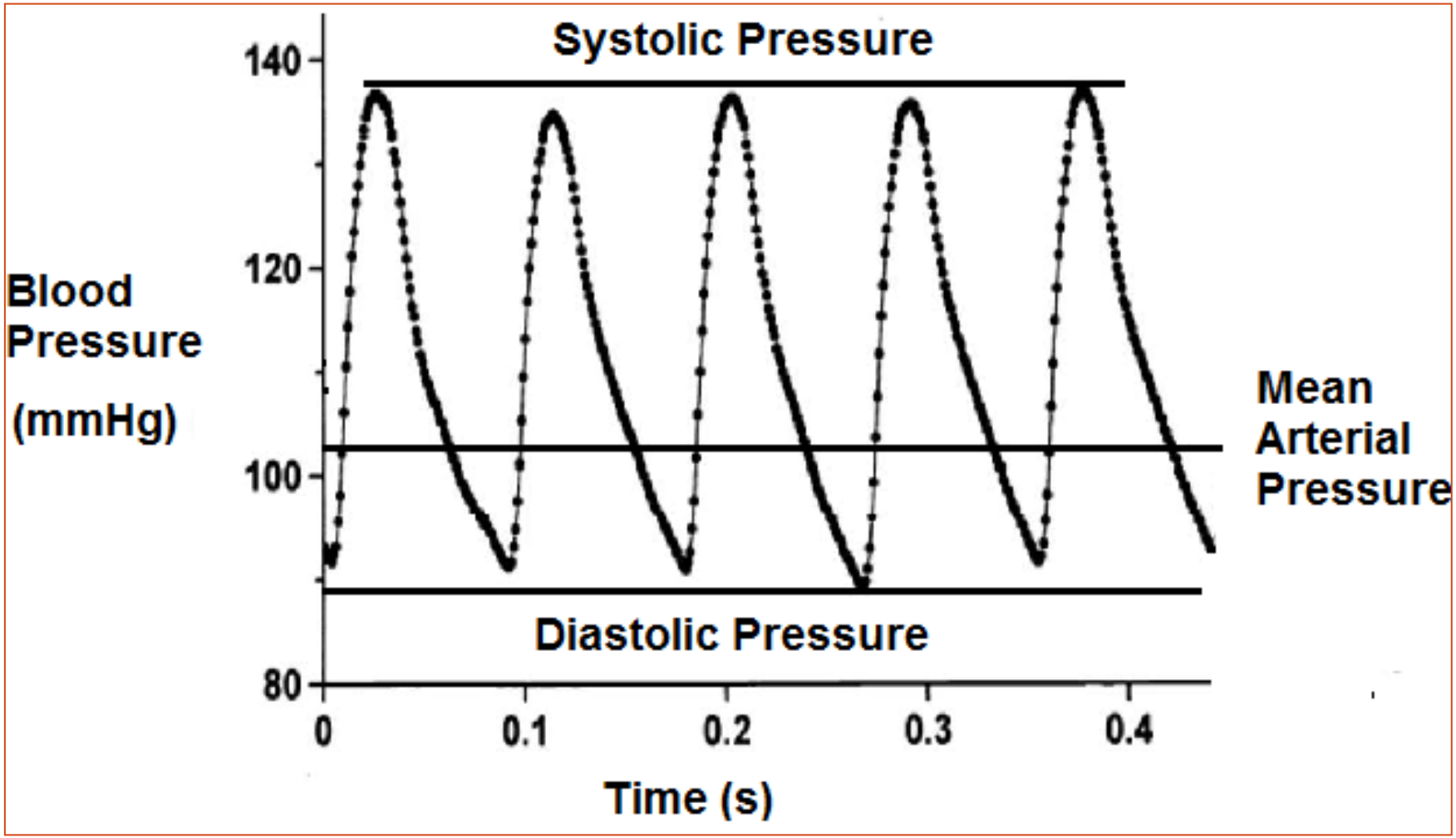
✓ It is the average pressure in the arteries throughout cardiac cycle.

✓ It is calculated by the following formula:

Mean arterial BP = Diastolic BP + 1/3 Pulse Pressure

= 80 + 1/3 x 40 = about 93 mm Hg.

Arterial Blood Pressure



Importance of mean ABP

- Normal mean ABP **provides the force that drives blood** to the tissues i.e. ensures steady blood flow (perfusion) to the tissues.

- Normal **diastolic blood pressure** is needed for filling of the coronary arteries with blood which occurs mainly during ventricular diastole.

Physiological variations in ABP

1. AGE:

- ✓ At birth, the ABP is about 80/40
- ✓ At the age of 20 years, the ABP is about 120/ 80
- ✓ The ABP tends to increase with age e.g. it becomes about 150/90 at the age of 60 years.

2. SEX:

- ✓ The ABP is slightly higher in adult males than adult females
- ✓ After menopause (stoppage of menstrual cycle in females which occurs usually at the of 45 years), the ABP may be the same in females and males, but sometimes it becomes higher in females, probably due to hormonal change.

Physiological variations in ABP

3. Body Built:

- ✓ The ABP of obese persons is usually higher than that of persons with normal body weight.
- ✓ Also, obese persons have higher tendency to develop hypertension.

4. Exercise:

- ✓ the ABP (systolic BP) increases during muscular exercise (due to increase of cardiac output) but it drops to pre-exercise level during recovery.
- ✓ the diastolic BP may remain unchanged or it is slightly decreased due to vasodilatation of the arterioles of the active skeletal muscles.

Physiological variations in ABP

5. Emotions:

- ✓ ABP (mainly systolic) increases during emotions due to sympathetic over activity.

6. Meals:

- ✓ ABP rises slightly after meals.

7. Sleep:

- ✓ ABP decreases slightly during sleep.
- ✓ When sleep is accompanied with dreams (nightmares) of emotional or motor activity, the ABP may increase to high levels.

Control of ABP

Factors that determine and maintain ABP:

1. Cardiac output.
2. Peripheral vascular resistance
3. Arterial elasticity
4. Blood volume

- ABP is related to the cardiac output and peripheral resistance according to the following equation:

ABP = Cardiac output x Peripheral resistance

1. Cardiac Output

- Normal CO is essential for normal ABP.
- ✓ ABP is directly proportional to CO (provided that all other factors affecting ABP remain constant).
- ✓ Change in CO affects systolic BP more than diastolic BP.

CO = Heart rate x Stroke volume

- **Effect of change in stroke volume:**
- ✓ Changes in SV affect systolic BP more than diastolic BP. Thus, ↑ SV → ↑ systolic BP & ↓ SV → ↓ systolic BP.
- ✓ The diastolic BP shows little or no change.

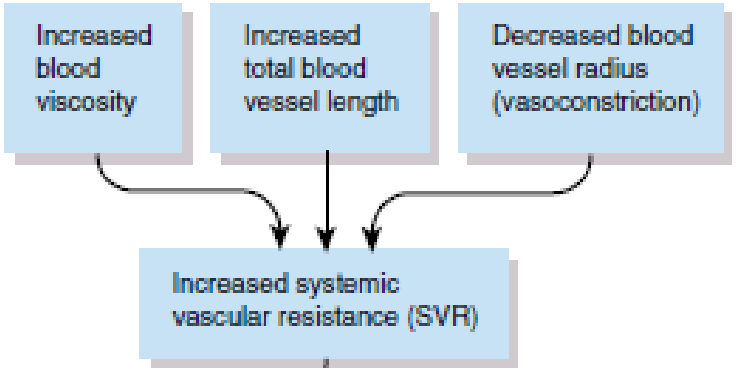
- **Effect of change in heart rate:**
- ✓ Changes in HR affect diastolic BP more than systolic BP i.e. ↑ heart rate → ↑ of diastolic BP & ↓ HR → ↓ diastolic BP.
- ✓ Systolic BP shows little or no change.

2. Peripheral Vascular Resistance (PVR)

- PVR is the resistance which blood meets during its passage in the peripheral arterioles and to a smaller extent in the blood capillaries.

- ✓ ABP is directly proportional to PVR. Changes in the peripheral resistance affect diastolic BP more than systolic BP.
- ✓ The PVR depends mainly on 3 factors:

1. **Diameter (radius) of arterioles**
2. **Blood viscosity**
3. **Length (L) of the blood vessel**



Factors that determine the peripheral resistance

a) Diameter of arterioles

The PVR is inversely proportional to the diameter of arterioles.

- ✓ Vasoconstriction of arterioles → ↓ of their diameter → ↑ PVR → ↑ ABP (manly diastolic)

- ✓ Vasodilatation of arterioles → ↑ of their diameter → ↓ PVR → ↓ ABP (mainly diastolic)

Factors that determine the peripheral resistance

b) Blood Viscosity

- ✓ PVR is directly proportional to the blood viscosity.

- ✓ Blood viscosity depends on 2 factors

1. HV (haematocrit value)
2. Plasma proteins

- ✓ ↑ Blood viscosity as in polycythaemia → ↑ PVR → ↑ ABP
- ✓ ↓ blood viscosity as in severe anemia or hypoproteinaemia → ↓ PVR → ↓ ABP

Factors that determine the peripheral resistance

c) Length (L) of the blood vessel

- ✓ The PVR varies directly with the length of the blood vessel (i.e. PR α L)

- ❑ ***However, the radius (diameter) is the most important factor that determines the PVR because both viscosity of blood and blood vessel length are normally constant.***

Regulation of the diameter of the arterioles

- The diameter of arterioles is regulated by 2 mechanisms (nervous and chemical):

1. Nervous Regulation

- ✓ The diameter of arteriole is under the control of the vaso-motor center (VMC) present in the medulla oblongata and the vasoconstrictor (VC) sympathetic tone (from VMC) to the arterioles)
- ✓ The activity of the VMC is modified by impulses from the arterial baroreceptors, chemoreceptors, atrial receptors and other receptors e.g. in skeletal and skin
- ✓ The VMC discharges continuous vasoconstrictor impulses through sympathetic nerve fibers to the various arterioles to keep them in a state of moderate or partial vasoconstriction. This is called vasomotor <u>tone</u> and it is important to maintain normal ABP.
- ➢ ↑ vasomotor tone → more constriction of the arterioles → ↑ PVR → ↑ ABP
- ➢ ↓ vasomotor tone → less constriction of the arterioles → VD → ↓ PVR → ↓ ABP

Regulation of the diameter of the arterioles

2. Chemical Regulation

- ✓ The arterioles show VD or VC by some chemical or hormonal agents.
- ✓ Vasoconstrictor substance e.g. noradrenalin, vasopressin (ADH) & angiotensin II
- ✓ Vasodilator substances e.g. metabolites, acetylcholine, histamine and bradykinine.

3. Elasticity of the arterial walls

- The elasticity of the wall of the aorta and its large branches buffers excessive changes in ABP during each cardiac cycle

- **During ventricular systole**

  The aorta distends and its capacity is increased to accommodate for the ejected blood pressure from the left ventricle. This prevents the systolic BP from reaching high level.

3. Elasticity of the arterial walls

- **During ventricular diastole**

The aorta recoils and its capacity is decreased. This prevents the diastolic BP from reaching a low level. Therefore, elastic recoil of the arterial wall is important for maintenance of normal diastolic BP.

The elastic recoil of the arterial wall is also useful in pushing the blood towards the tissues during diastole.

3. Elasticity of the arterial walls

- **In arterioscleroses**

  The arterial elasticity is decreased → ↑ systolic BP ↓ diastolic BP.

Normal diastolic BP is produced and maintained by:

- ✓ Elastic recoil of aorta and large arteries.
- ✓ Normal degree of peripheral resistance.

Normal diastolic BP is important for:

- ✓ Filling of the coronary arteries which occurs mainly during ventricular diastole.
- ✓ Maintenance of blood flow to the tissues during ventricular diastole

4. Blood Volume

- Normal blood volume (5-6 liters) is important for normal ABP (systolic and diastolic)

- ✓ **Slight or moderate change in the blood volume** → almost no effect on ABP due to some compensatory reaction in the CVS that restore normal BP

  e.g. Moderate ↓ of blood volume → baroreceptors reflex → ↑ heart rate and vasoconstriction of arterioles → ↑ ABP towards normal.

- ✓ **Marked or excessive decrease** of blood volume e.g. after severe haemorrhage → decrease of ABP (hypotension as hemorrhagic shock). This occurs because the compensatory reactions are not sufficient to restore normal BP.


Thank You