CARDIAC OUTPUT

Cardiac output: The amount of blood pumped out by each ventricle per min. It is about 5-6 L/min.

Cardiac output = Stroke volume × heart rate.

Cardiac index:
Cardiac output per square meter body surface area is called cardiac index.
It is about 3.5 L/min/sq. meter body surface area.

In male:3.3L/min/sq meter
In female: 3.1L/min/sq meter
At 10 years: 4 L/min/sq meter
At 80 years: 2.4 L/min/sq meter

Factors regulating cardiac output:

1. **Heart rate:** Cardiac output is directly proportional to heart rate.

   Sympathetic stimulation → ↑Heart rate → ↑cardiac output

   Parasympathetic stimulation → ↓Heart rate → ↓cardiac output

   Maximum effective heart rate in man is 180 beats/min. If heart rate increases above 180 beats/min cardiac output will be decreased.

   When tachycardia is severe filling time is greatly reduced & ventricular filling will be less & the cardiac output will be reduced.

2. **Force of contraction of heart:** Cardiac output is directly proportional to force of contraction of heart.

   ↑ Force of contraction → ↑Stroke volume → ↑Cardiac output

3. **Venous return:** Cardiac output is directly proportional to venous return.

   ↑ Venous return ⟶ ↑EDV ⟶ ↑Cardiac muscle fiber length
   ↑Strength of contraction ⟶ ↑Stroke volume ⟶ ↑Cardiac output

4. **Peripheral resistance:** Increased peripheral resistance decreased cardiac output.

   ↑Peripheral resistance ⟶ ↓Venous return ⟶ ↓EDV
   ↓Stroke volume ⟶ ↓Cardiac output

5. **Ejection fraction**: It also influences the amount of cardiac output.

- **Peripheral resistance:** It is the resistance which blood has to be overcome while passing through periphery**.**
- **Heterometric regulation :** Regulation of cardiac output as a result of changes in cardiac muscle fiber length.
- **Homometric regulation:** Regulation due to changes in contractility independent on length.
- **Preload:** Degree to which myocardium is stretched before its contraction.
- **Afterload:** Resistance against which blood is expelled.

Factors affecting cardiac output:

- Age: ↑Age ⟶ ↓cardiac output
- Sex: 10-20% less in female than in male due to less body weight & surface area.
- Surface area: Cardiac output is directly proportional to surface area.
- Posture: Cardiac output is increased in sitting & lying posture than in standing position (20-30%), because venous return is less in standing position.

- Exercise: Increase cardiac output by increasing venous return & heart rate.
- Emotion, excitement, anxiety: ↑cardiac output.
- Pregnancy: ↑cardiac output
- Epinephrine: ↑cardiac output
- Temperature: ↑temperature → ↑heart rate → ↑cardiac output
- Cardiac output is directly proportional to metabolic rate.

High cardiac output:

High cardiac output caused by reduced total peripheral resistance. Found in patient with beriberi, arteriovenous fistula (shunt), hyperthyroidism and anemia.

Low cardiac output:

When the heart becomes severely damaged, its limited level of pumping may fall below that needed for adequate blood flow to the tissues. Some examples of this include-

- severe coronary blood vessel blockage and consequent myocardial infarction,
- severe valvular heart disease,
- myocarditis,
- cardiac tamponade, and
- cardiac metabolic derangements

Methods of cardiac output measurement:

i. Fick principale method.

ii. Indicator dilution technique.

Purpose of cardiac output measurement:

1. For investigation of congenital & acute heart disease.
2. For investigation of cardiac septal defect.

Fick principle:

Fick principle states that the amount of a substance taken up by an organ (or by the whole body) per unit of time is equal to the arterial level of the substance minus the venous level (A-V difference) times the blood flow.

Fick principle method for measurement of cardiac output :

The principle can be used to determine cardiac output by measuring the amount of O_2 consumed by the body in a given period & dividing this value by the arterio-venous (A-V) O_2 difference.

The arterial blood is collected from any convenient artery & sample of venous blood is collected from pulmonary artery by means of a cardiac catheter.

$$\text{Cardiac output} = \frac{O_2 \text{ consumption by the lungs (ml/min)}}{\text{Arterial level of } O_2\,(AO_2) - \text{Venous level of } O_2\,(VO_2)}$$

$$= \frac{200 \text{ ml/min}}{(200 - 160) \text{ ml/L}}$$

$$= \frac{200 \text{ ml/min}}{40 \text{ ml/L}}$$

$$= 5 \text{ L/min}$$

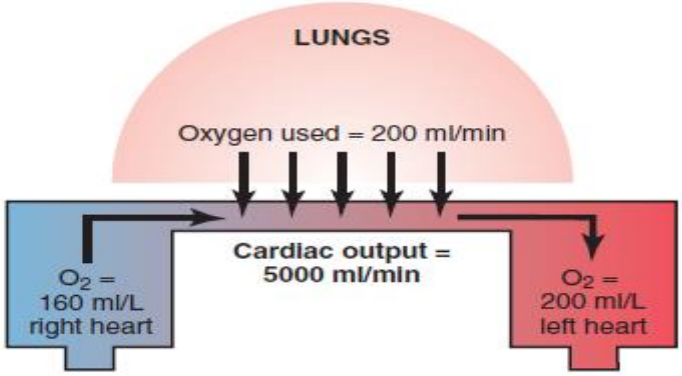

Fig: Fick principle for determining cardiac output