

CARDIOVASCULAR SYSTEM: CARDIAC OUTPUT

For:

Semester II

CC2TH/ GEN 2TH

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DEFINITION

- Amount of blood ejected by each ventricle per minute.
- **CO = SV * HR**
 - SV – Stroke Volume.
 - HR – Heart rate.
- **Cardiac output = 80 * 70 = 5.6 L/min.**
- Cardiac output decides the rate of blood flow to the different parts of the body.
- Decrease in cardiac output  Decrease in blood flow

- For young, healthy men, resting cardiac output averages about 5.6 L/min.
- For women, this value is about 4.9 L/min
- Cardiac output is frequently stated in terms of the **cardiac index**, which is the cardiac output per square meter of body surface area. The average human being who weighs 70 kg has a body surface area of about 1.7 sq meters, which means that the normal average cardiac index for adults is about 3 L/min/m² of body surface area.

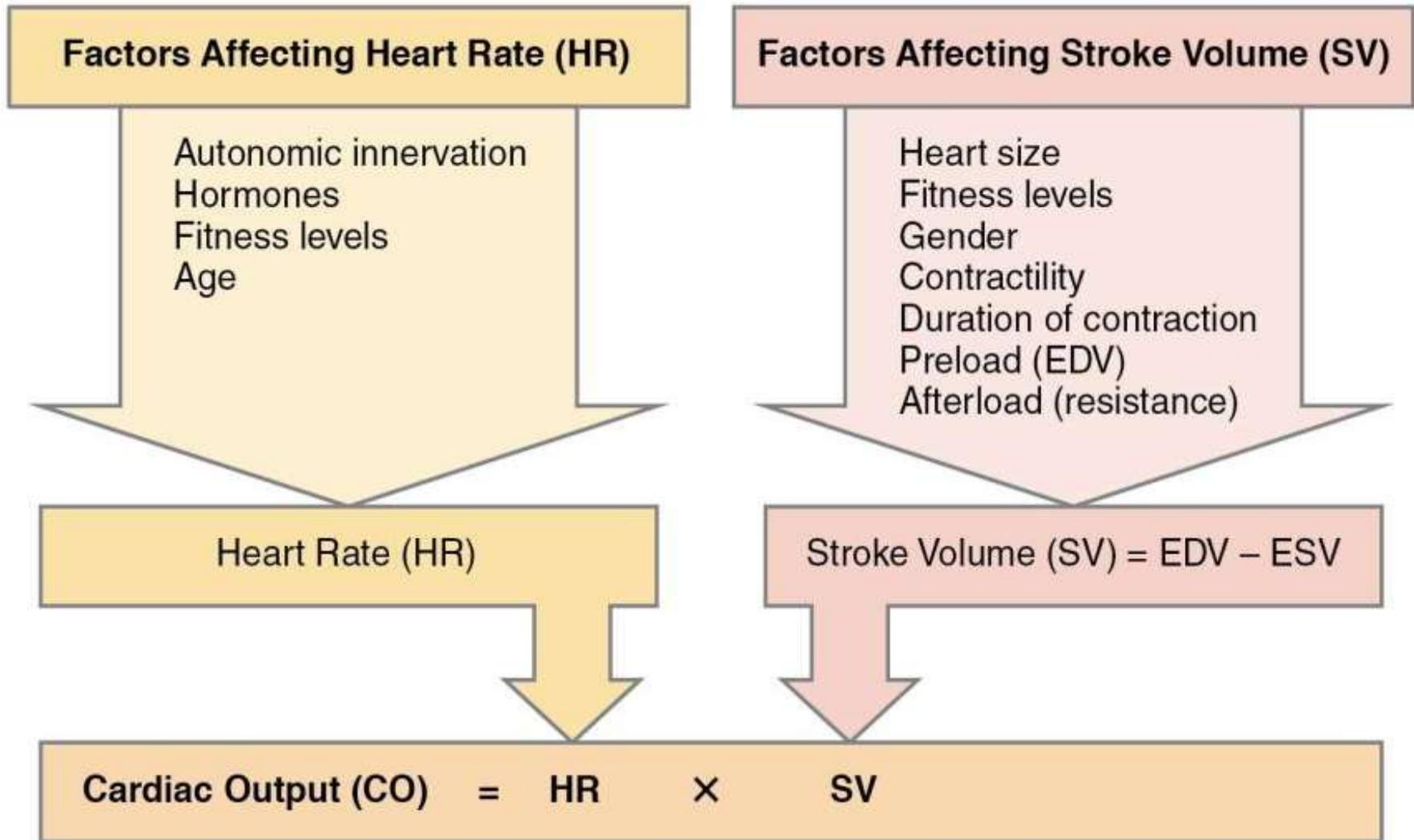
COMPONENTS

STROKE VOLUME

- Amount of blood pumped by each ventricle per beat or per contraction. Approx 80 ml.
- Stroke volume depends on –
 - **End diastolic volume**
 - **Contractility**

HEART RATE

- Under normal circumstances 70 times/min.
- Increase in heart rate increases cardiac output but up to a limit after which it decreases due to **decrease in cardiac filling.**



Major Factors Influencing Cardiac Output. Cardiac output is influenced by heart rate and stroke volume, both of which are also variable.

FACTORS MAINTAINING CARDIAC OUTPUT

Cardiac output is maintained by four factors:

- **Venous return**
- **Force of contraction**
- **Heart rate**
- **Peripheral resistance**

➤ VENOUS RETURN

- It is the quantity of blood returned from all over the body through the veins into the right atrium each minute.

- The cardiac output is directly proportional to venous return providing other three factors remain the same.

- Venous return in turn, depends on following factors

- ✓ Respiratory pump

- ✓ Muscle pump

- ✓ Gravity

- ✓ Venous pressure

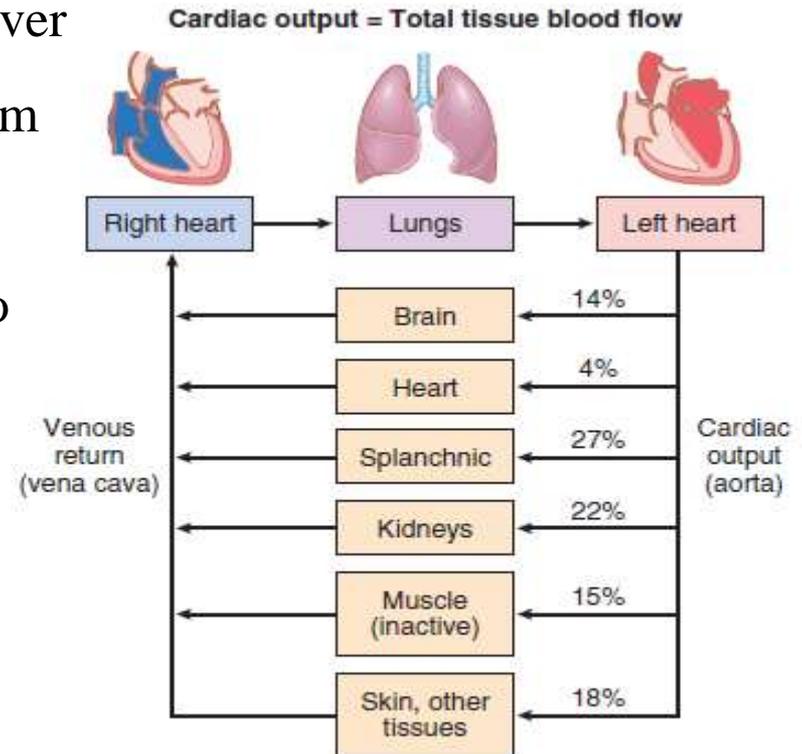
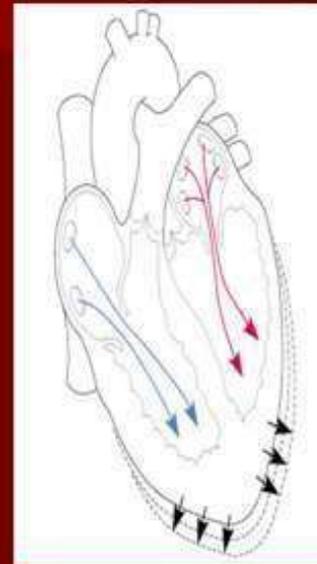


Figure 20-2. Cardiac output is equal to venous return and is the sum of tissue and organ blood flows. Except when the heart is severely weakened and unable to adequately pump the venous return, cardiac output (total tissue blood flow) is determined mainly by the metabolic needs of the tissues and organs of the body.

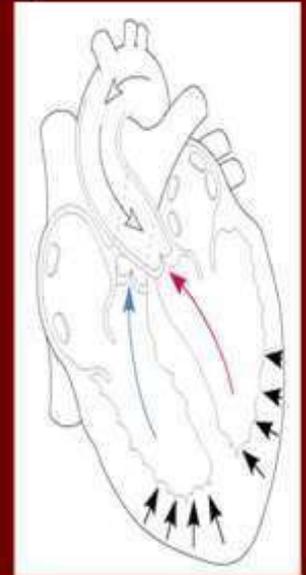
➤ FORCE OF CONTRACTION

Frank - Starling law of the heart states that when increased volume of blood flows into the heart, the cardiac muscle contracts with increased force and this empties the extra blood that has entered from the systemic circulation leading to increased cardiac output.

Frank Starling Law of the Heart



=



Increased blood volume =
increased stretch of myocardium

Increased force to pump blood
out.

PRELOAD

- It is stretching of cardiac muscle fibre at the end of diastole, just before contraction
- Cardiac output is directly proportional to pre-load

AFTERLOAD

- It is the force against which ventricles must contract and eject the blood.
- Force of contraction and cardiac output is inversely proportional to after-load.

➤ HEART RATE

When heart rate increases, cardiac output also increases.
Any factor which changes heart rate will also change cardiac output.

PERIPHERAL RESISTANCE

- Peripheral resistance is the resistance offered to blood flow at the peripheral blood vessels.
- Peripheral resistance is the resistance or load against which the heart has to pump the blood.
- Cardiac output is inversely proportional to peripheral resistance.

MEASUREMENT OF CARDIAC OUTPUT

- **FICK'S PRINCIPLE** – Amount of substance taken up by an organ per unit of time (Q) is equal to the arterial level of the substance (A) – venous level of substance (V) \times Blood flow (F)

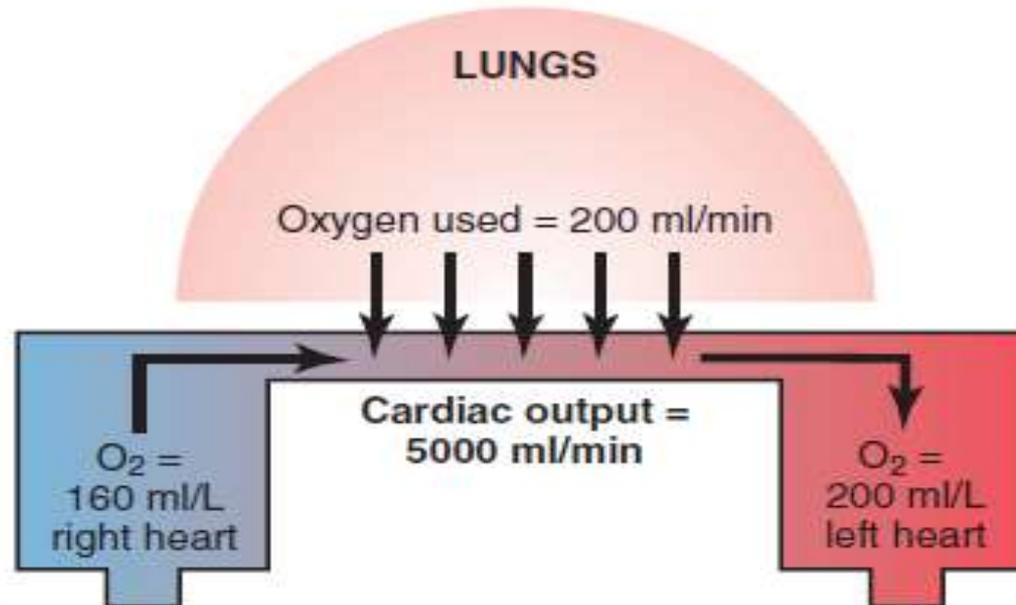


Figure 20-19. Fick principle for determining cardiac output.

MEASUREMENT OF CARDIAC OUTPUT USING THE OXYGEN FICK PRINCIPLE

The Fick principle is explained by [Figure 20-19](#). This figure shows that 200 milliliters of oxygen are being absorbed from the lungs into the pulmonary blood each minute. It also shows that the blood entering the right heart has an oxygen concentration of 160 ml/L of blood, whereas that leaving the left heart has an oxygen concentration of 200 ml/L of blood. From these data, one can calculate that each liter of blood passing through the lungs absorbs 40 milliliters of oxygen.

Because the total quantity of oxygen absorbed into the blood from the lungs each minute is 200 milliliters, dividing 200 by 40 calculates a total of five 1-liter portions of blood that must pass through the pulmonary circulation each minute to absorb this amount of oxygen. Therefore, the quantity of blood flowing through the lungs each minute is 5 liters, which is also a measure of the cardiac output. Thus, the cardiac output can be calculated by the following formula:

$$\text{Cardiac output (L/min)} = \frac{\text{O}_2 \text{ absorbed per minute by the lungs (ml/min)}}{\text{Arteriovenous O}_2 \text{ difference (ml/L of blood)}}$$

In applying this Fick procedure for measuring cardiac output in humans, *mixed venous blood* is usually obtained through a catheter inserted up the brachial vein of the forearm, through the subclavian vein, down to the right atrium, and, finally, into the right ventricle or pulmonary artery. *Systemic arterial blood* can then be obtained from any systemic artery in the body. The *rate of oxygen absorption* by the lungs is measured by the rate of disappearance of oxygen from the respired air, using any type of oxygen meter.

VARIATIONS IN CARDIAC OUTPUT

➤ PHYSIOLOGICAL CAUSES

- Age- ↑ses with age
- Sex- less in females more in males
- Body build- ↑ses with body build
- Exercise- ↑ses with exercise
- High altitude- ↑ses
- Pregnancy- ↑ses
- Sleep- ↓ses

➤ **PATHOLOGICAL CAUSES**

- **Increase**

1. Fever
2. Anemia
3. Hyperthyroidism

- **Decrease**

- Hypothyroidism

1. Shock
2. Hypovolemia
3. Hemorrhage
4. Congestive cardiac failure

THANK YOU!!

REFERENCE

- 1. Guyton and Hall Textbook of Medical Physiology, 13th edition**
- 2. <https://opentextbc.ca/anatomyandphysiology/chapter/19-4-cardiac-physiology/>**
- 3. Essentials of Medical Physiology by K. Sembulingum & Prema Sembulingum**
- 4. Ganongs Review Of Medical Physiology 25th Edition**