Venous Return

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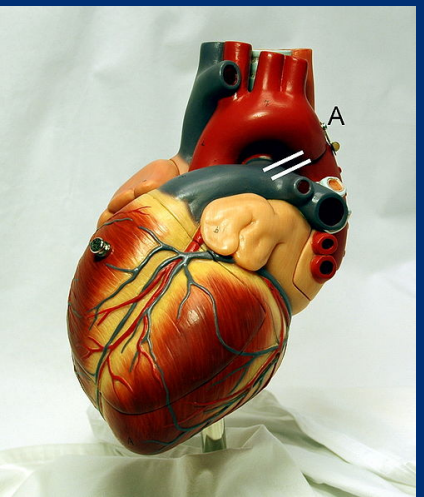


Objectives

- Define venous return and identity the factors controlling it
- Recognize the distribution of blood in different vessels
- Explain the venous curve and elation between the venous return and the right atrial pressure
- Identify the jugular venous pressure
- Know the method of examination of the internal venous pressure

Venous Return

Venous return is the quantity of blood flowing from large veins into the right atrium each min.

Factors controlling venous return :-

1- Skeletal muscle pump → ↑ venous return.

2- Pressure drop during inspiration → ↑ venous return.
Forceful expiration (Valsalva maneuver) → ↓ venous return.

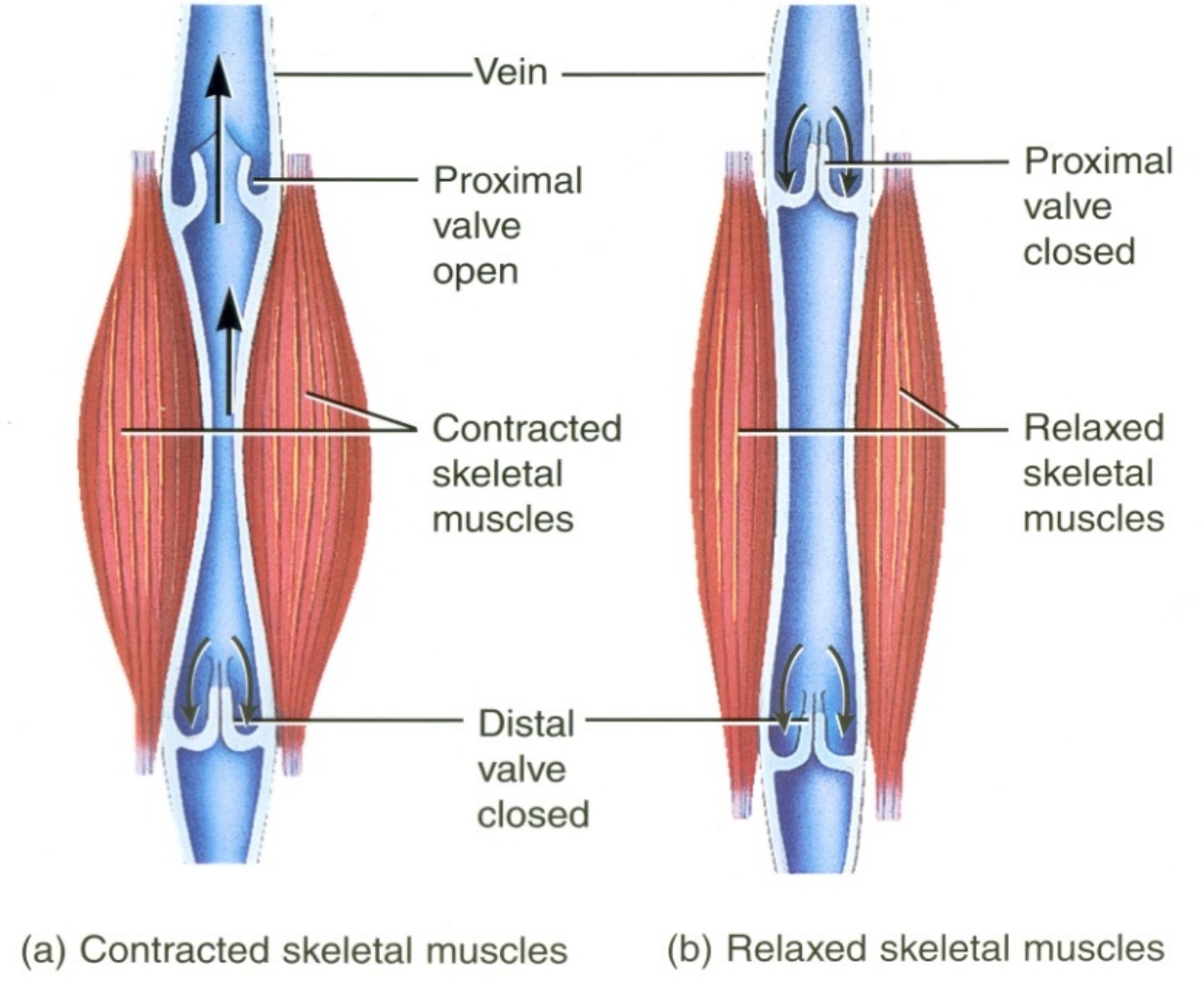
3- ↑Blood volume → ↑ venous return.

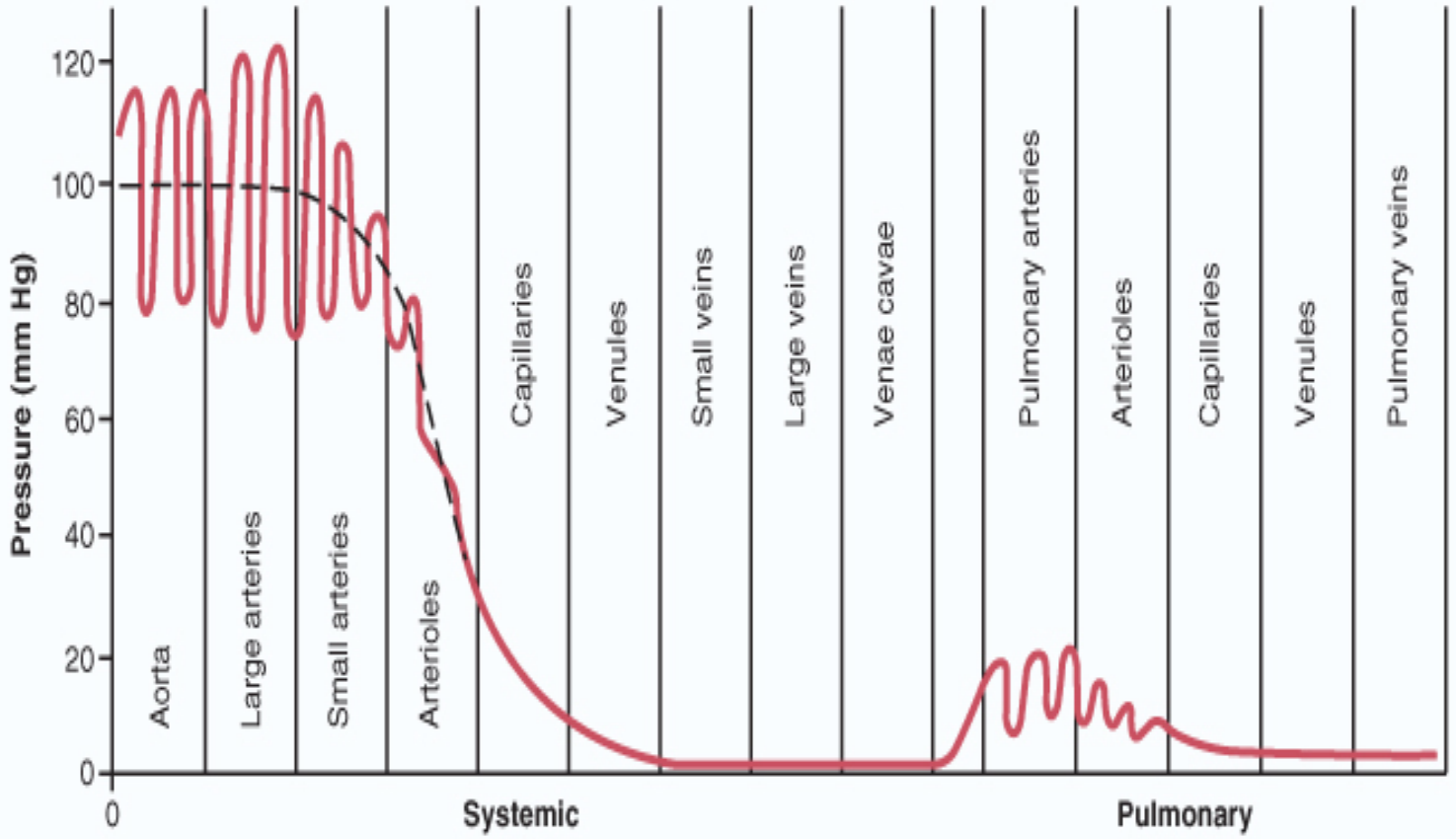
4- ↑Pressure gradient → ↑ venous return.

5- ↑Venous pressure → ↑ venous return.

6- Gravity → ↓ venous return.

Effect of Venous Valves





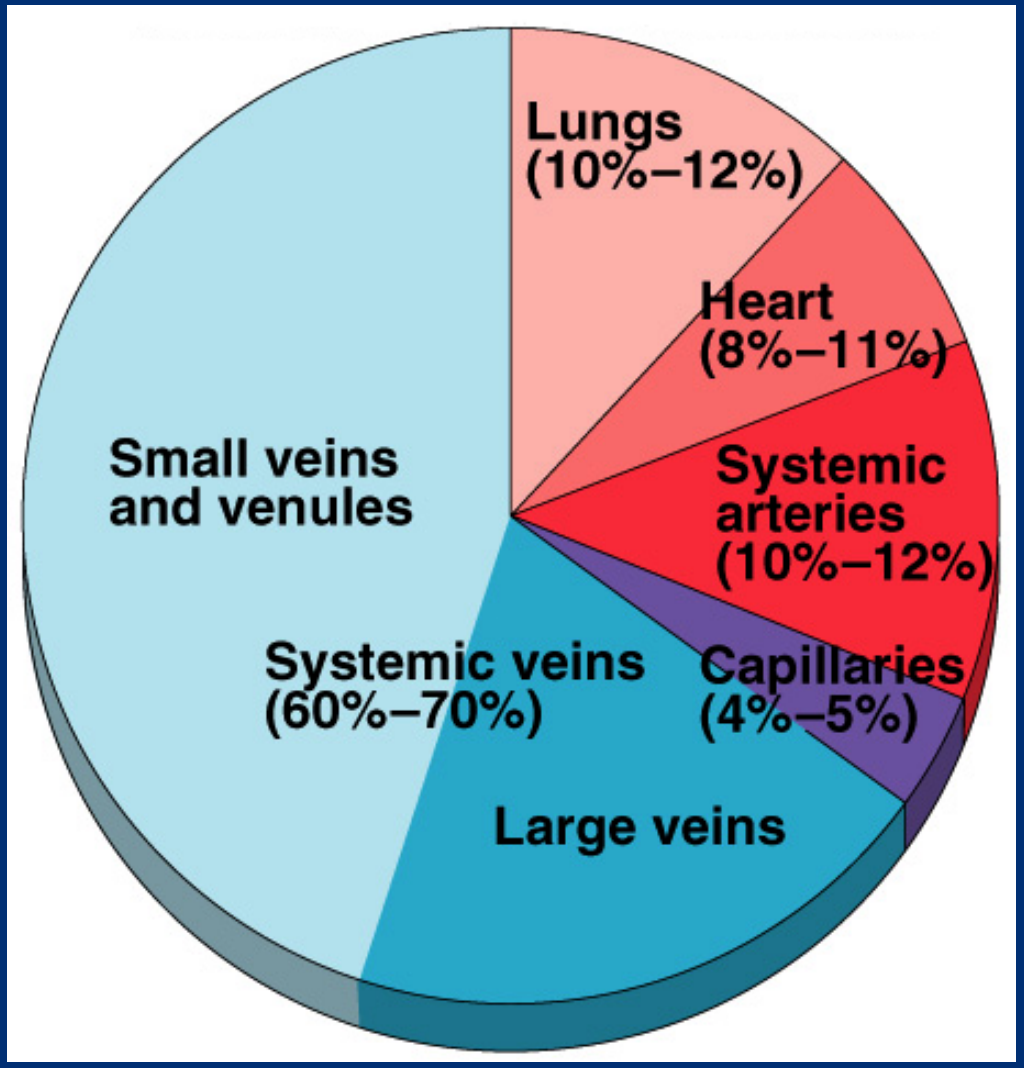
Venous Return

Veins hold most of blood in body (70%) & are thus called capacitance vessels

Have thin walls & stretch easily to accommodate more blood without increased pressure

(= higher compliance)

Have only 0 -10 mm Hg Pressure.



Venous Return

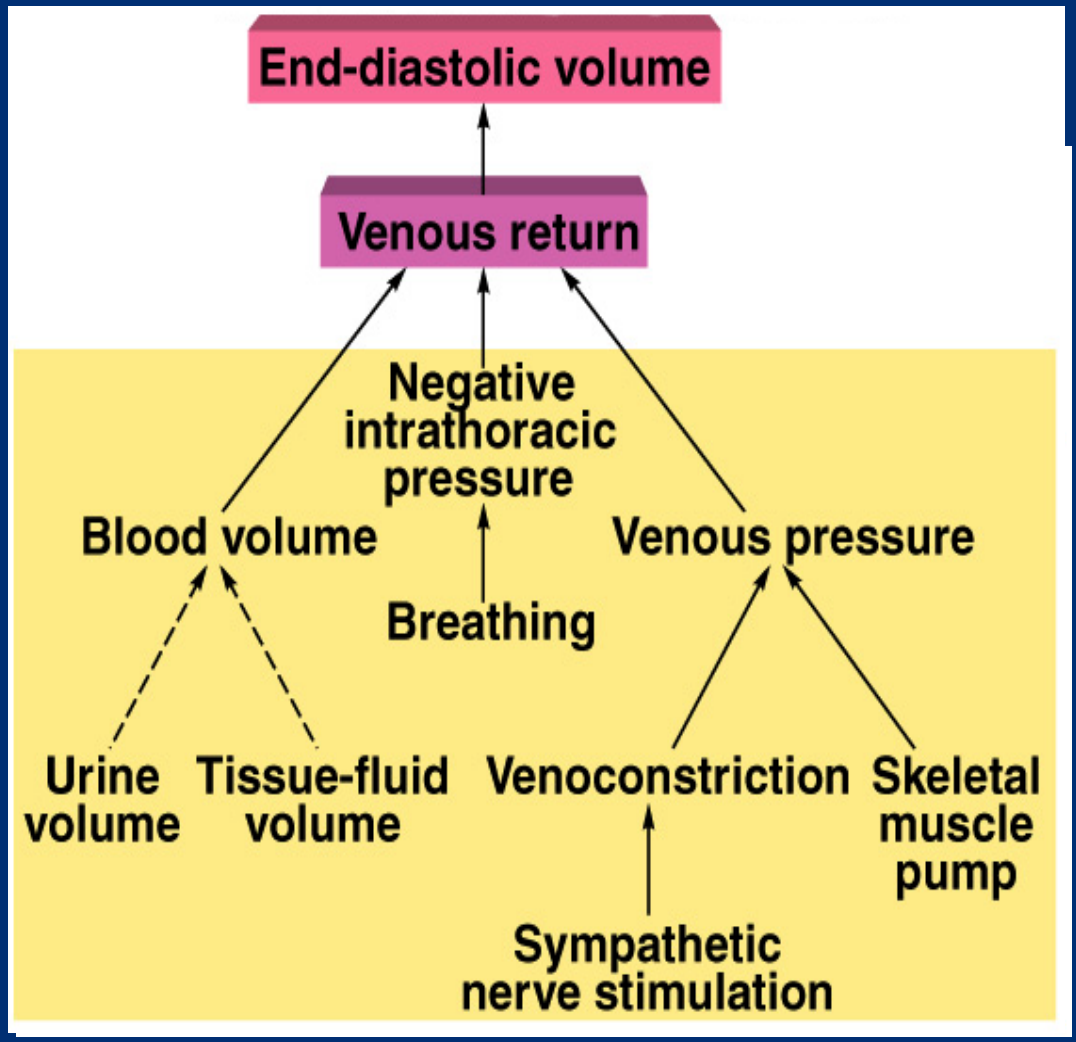
Dependens on:-

1- Blood volume & venous pressure.

2- Venoconstriction caused by Sympathetic

3- Skeletal muscle pumps.

4- Pressure drop during inhalation.



Venous return curve

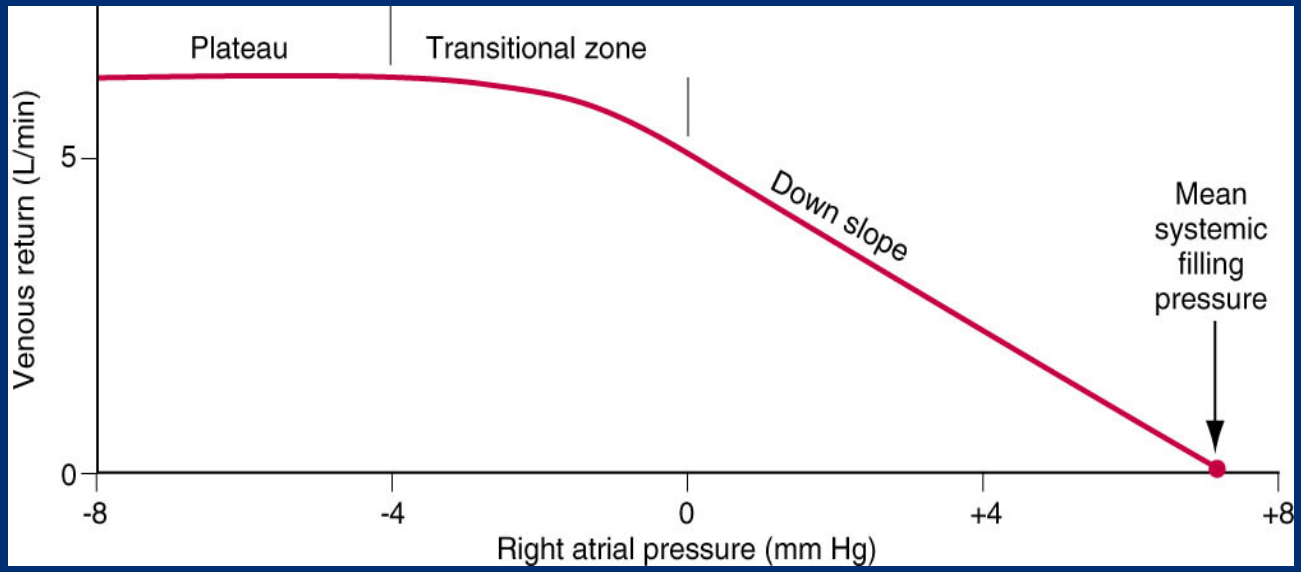
Venous return (VR) curve relates VR to right atrial pressure.

Venous return is decreased when:

1- The right atrial pressure (RAP) is increased,

2- Pumping capability becomes diminished.

3- The nervous circulatory reflexes are absent.



In Valsalva maneuvre (forceful expiration against a closed glottis) the intrapleural pressure become positive which is transmitted to the large veins in the chest → **decrease venous return**.

Venous return curve

- When the RAP falls below zero, no further increase in VR and a plateau is reached
- Plateau in the venous return curve at negative atrial pressures caused by

  collapse of the veins entering the chest.

- Mean Circulatory Filling Pressure is the value for right atrial pressure at which venous return is zero
  - When the heart is stopped by shocking the heart with electricity or any reason, flow of blood cease in the circulation.
  - Without blood flow, the pressures everywhere in the circulation become equal and is called : Mean Circulatory Filling Pressure.

Definition of:

- **Jugular Venous Pulse:**

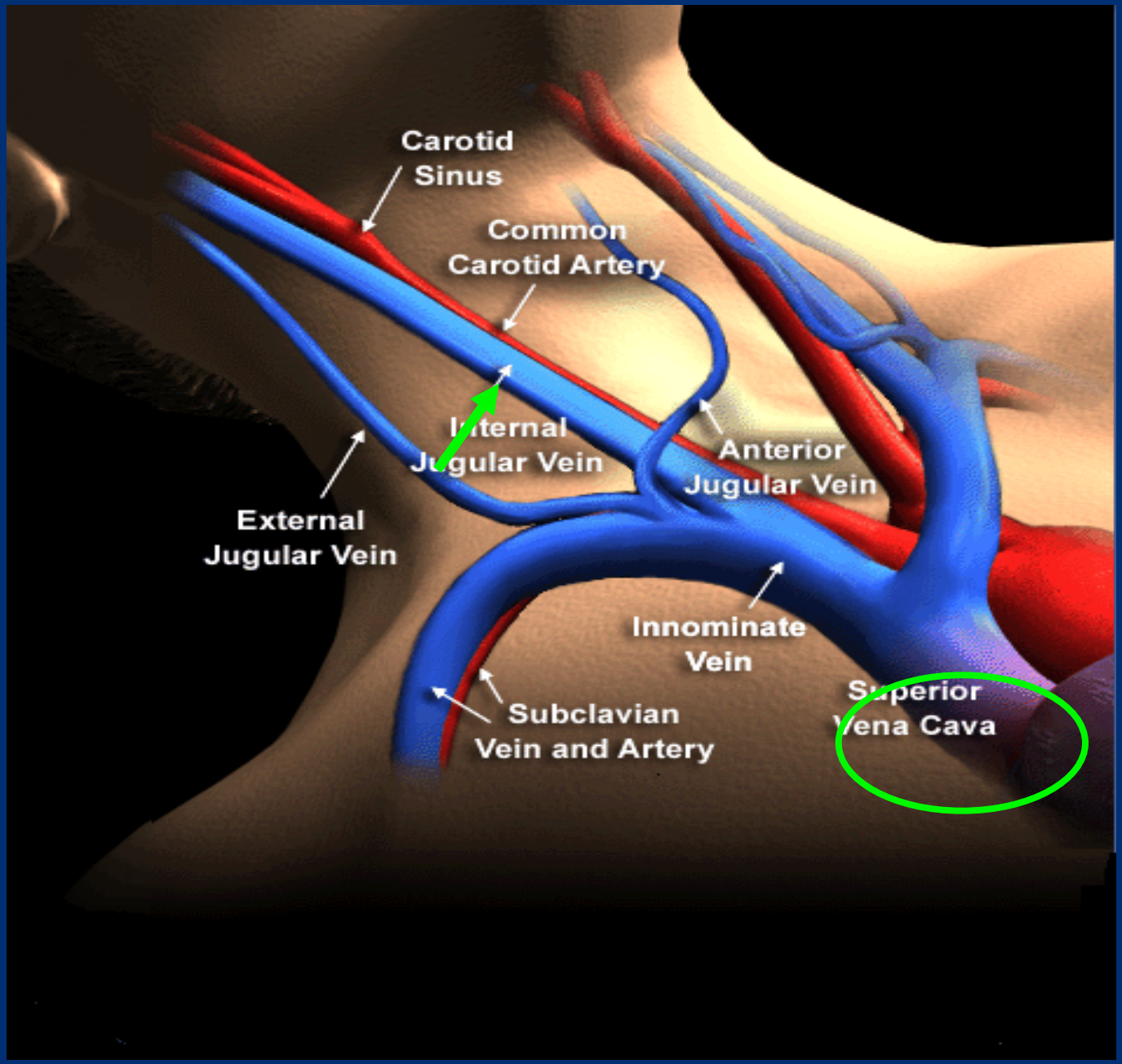
  Defined as the oscillating top of vertical column of blood in **right internal jugular vein** that reflects pressure **changes** in right atrium in cardiac cycle.

- **Jugular Venous Pressure:**

  Vertical height of oscillating column of blood.

Why Internal Jugular Vein (IJV)?

- IJV has a direct course to RA.
- IJV is anatomically closer to RA.
- IJV has no valves (Valves in EJV prevent transmission of RA pressure)


Carotid Sinus
Common Carotid Artery
Internal Jugular Vein
Anterior Jugular Vein
External Jugular Vein
Innominate Vein
Subclavian Vein and Artery
Superior Vena Cava

Why Right Internal Jugular Vein?

- Right jugular veins extend in an almost straight line to superior vena cava, thus favoring transmission of the haemodynamic changes from the right atrium.

- The left innominate vein is not in a straight line and may be kinked or compressed between Aortic Arch and sternum, by a dilated aorta, or by an aneurysm.

Method Of Examination

- The patient should lie comfortable during the examination.
- Clothing should be removed from the neck and upper thorax.
- Patient reclining with head elevated 45 °
- Neck should not be sharply flexed.
- Examined effectively by shining a light across the neck.
- There should not be any tight bands around abdomen

Observations Made

- the level of venous pressure.
- the type of venous wave pattern.

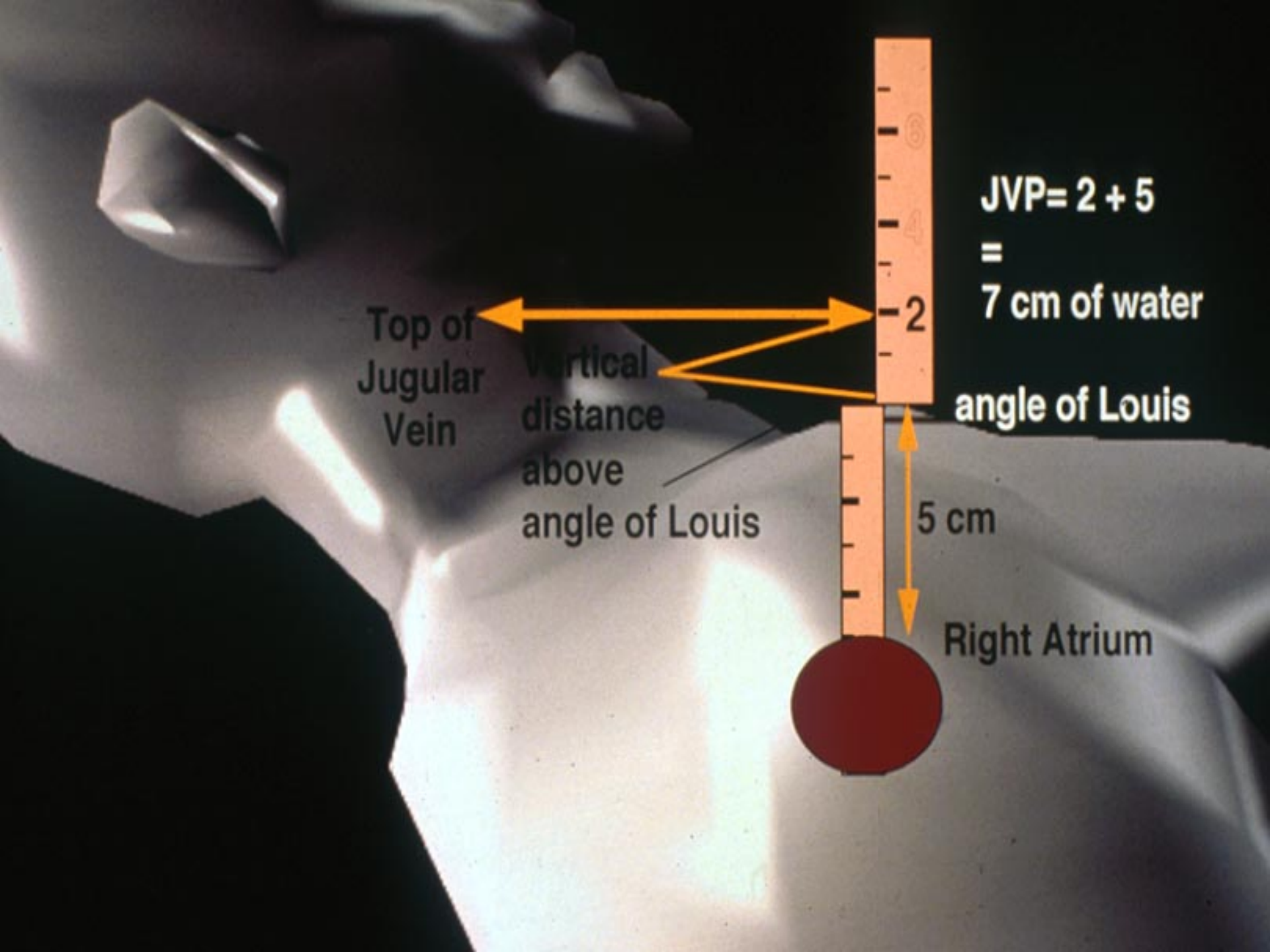
The level of venous pressure

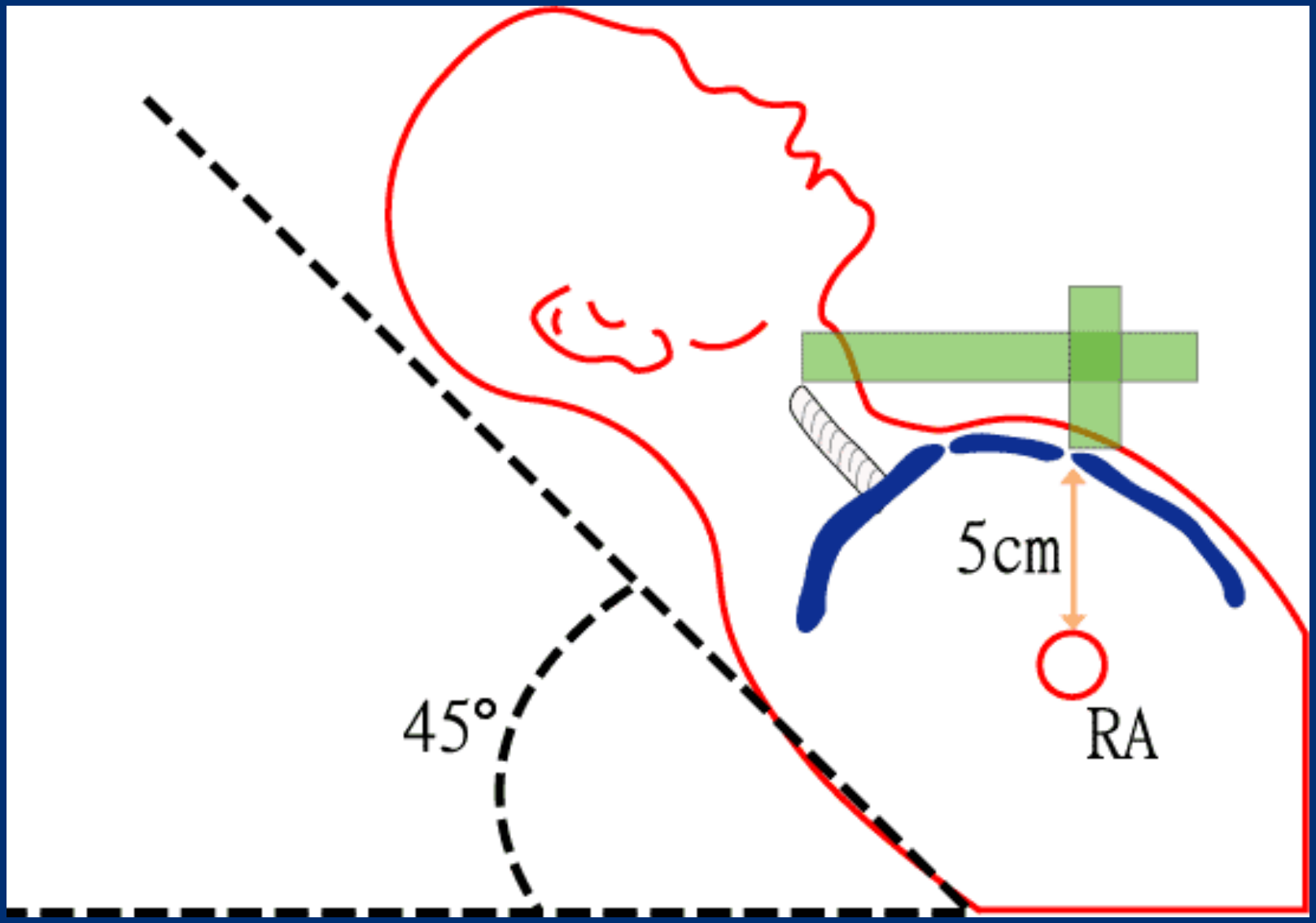
- Using a centimeter ruler, measure the vertical distance between the angle of Louis and the highest level of jugular vein pulsation.

- The upper limit of normal is 3 cm above the sternal angle.

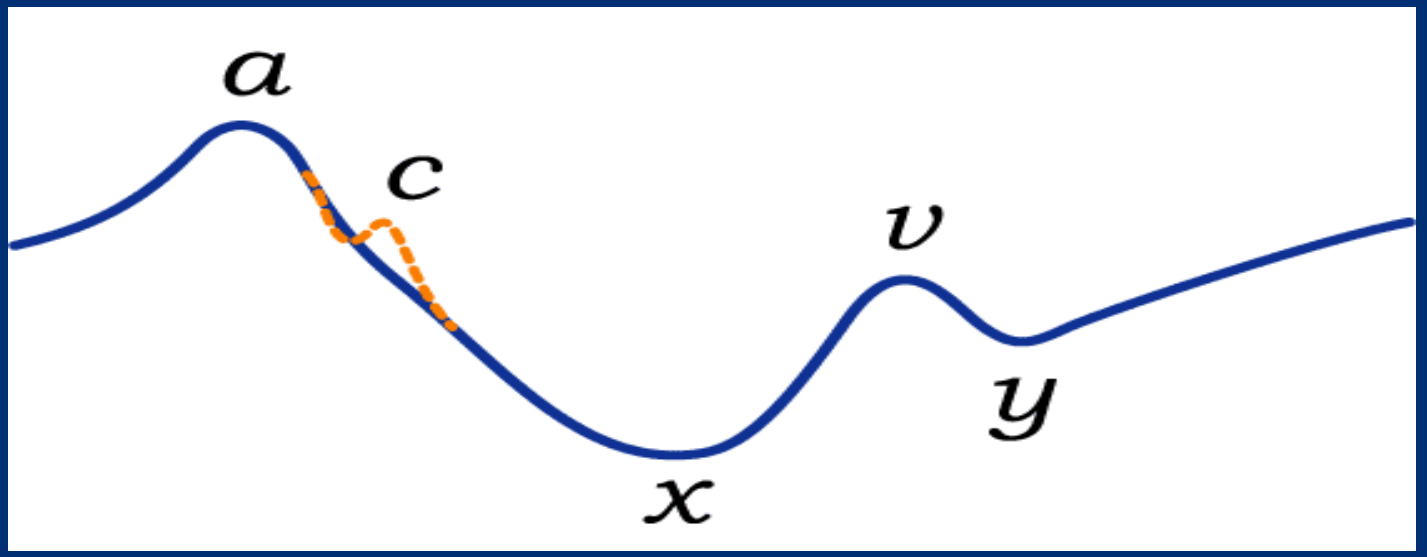
- Add 5 cm to measure central venous pressure since right atrium is 5 cm below the sternal angle.

- Normal CVP is < 8 cm H2O


JVP= 2 + 5
=
7 cm of water
Top of
Jugular
Vein
Vertical
distance
above
angle of Louis
angle of Louis
5 cm
Right Atrium


5cm
RA
45°

Normal pattern of the jugular venous pulse



- The normal JVP reflects phasic pressure changes in the right atrium and consists of three positive waves
- and two negative descents.

a WAVE

- Venous distension due to RA contraction
  Retrograde blood flow into SVC and IJV

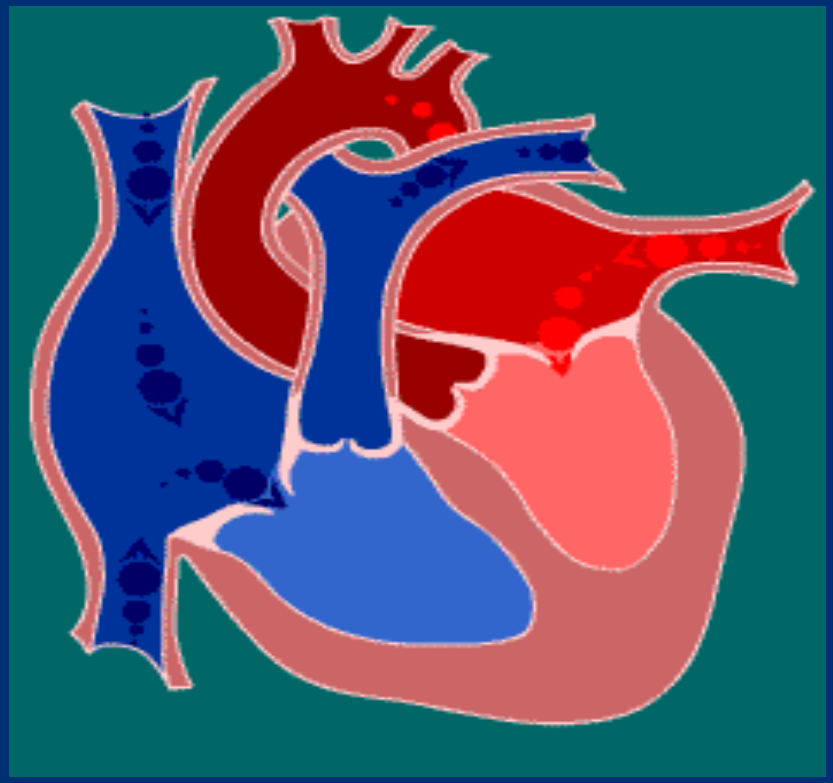
The x descent: is due to

Atrial relaxation and the tricuspid valve moves downward.

The c wave: is due to:

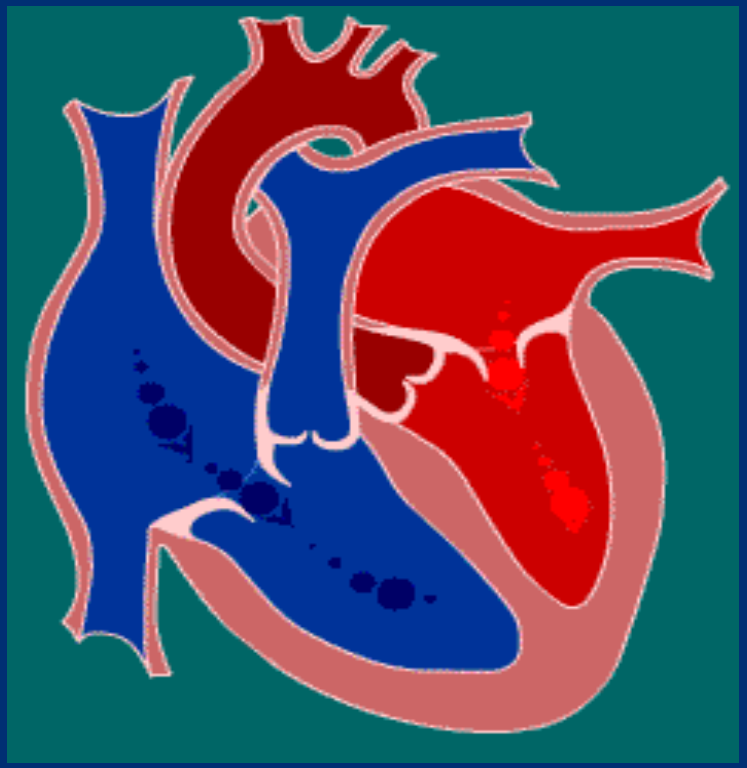
Ventricular contraction and resulting bulging of tricuspid valve into the right atrium during isovolumetric contraction.

v WAVE: is due to



- **Rising** right atrial pressure when blood flows into the right atrium during ventricular systole when the tricuspid valve is shut.

y DESCENT is due to



The decline in right atrial pressure when the tricuspid valve reopens

Abnormalities of jugular venous pulse

A- Low jugular venous pressure

1. Hypovolemia.

Raised Jugular Venous Pressure

Causes of a raised JVP may be classified into those due to:

1- Increased right ventricular filling pressure e.g in heart failure , fluid overload.

2- Obstruction of blood flow from the right atrium to the right ventricle e.g tricuspid stenosis.

3- Superior vena caval obstruction e.g retrosternal thyroid goitre.

4- Positive intrathoracic pressure e.g pleural effusion, pneumothorax.

The JVP usually drops on inspiration along with intrathoracic pressure.

Cardiac Output

The Cardiac Output (C.O.)

It is the volume of blood pumped from the heart per minute = 5 L/min. at rest.

C.O. = Heart rate x Stroke volume.

Stroke volume is the volume of blood pumped from each ventricle per beat = 70 ml /beat at rest.

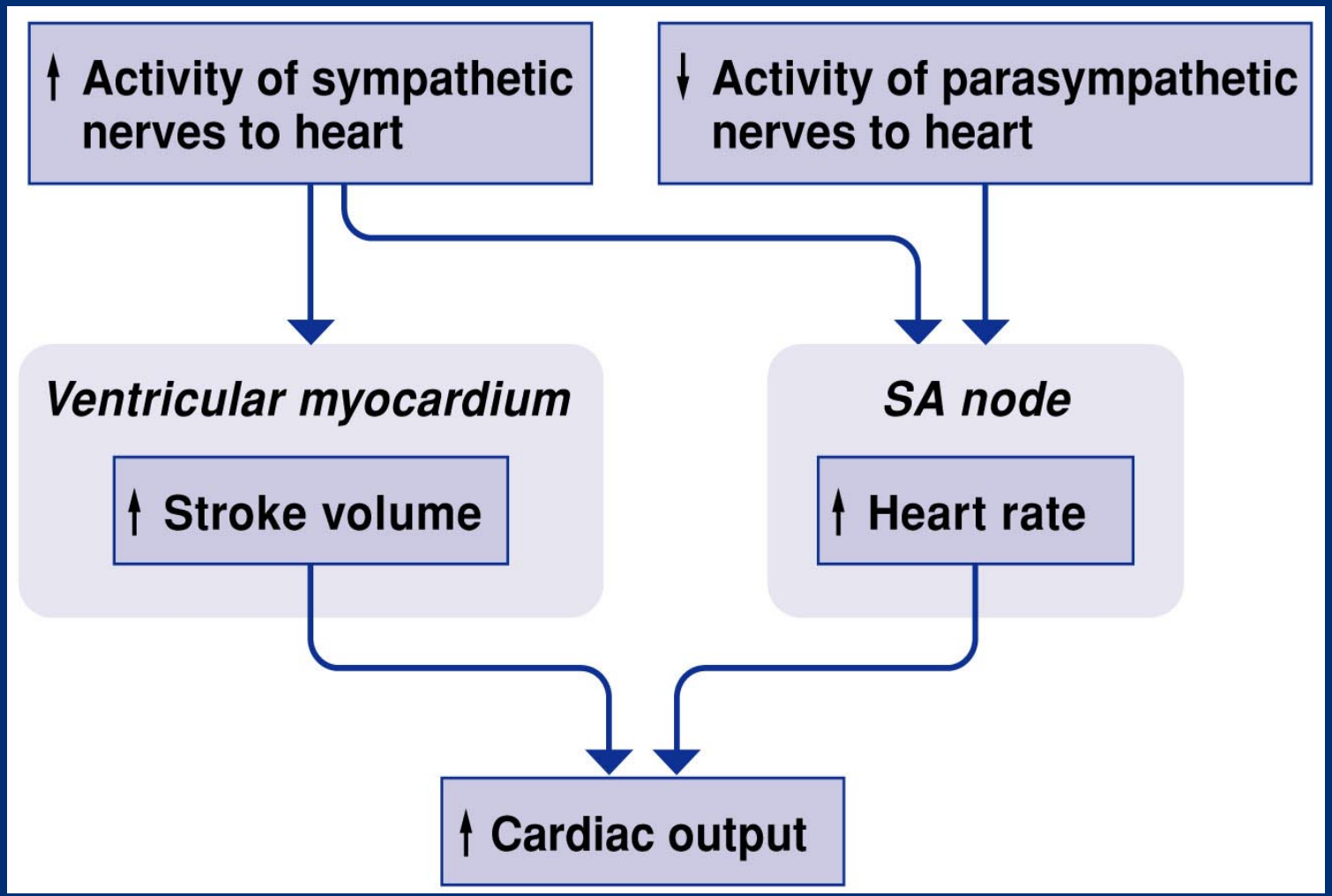
Heart rate at rest = 72 beats /min.

Normal Values of Cardiac Output at Rest

- **The factors affecting cardiac output are:**
  1. **Body metabolism**
  2. **Exercise**
  3. **Hyperthyroidism**
  4. **Pregnancy**
  5. **Increase body temperature.**

- **Resting cardiac output:**
  - **For men is 5.6 L/min**
  - **For women is about 4.9 L/min**
  - **The average cardiac output for the resting adult is 5L/min**

Regulation of Cardiac Output



Regulation of Heart Rate

Increased heart rate by:

1- Sympathetic nervous system

- Crisis
- Low blood pressure

2- Hormones

- Epinephrine
- Thyroxine

3- Exercise

4- Decreased blood volume

Regulation of Heart Rate

Atrial Reflex:

Also called Bainbridge reflex

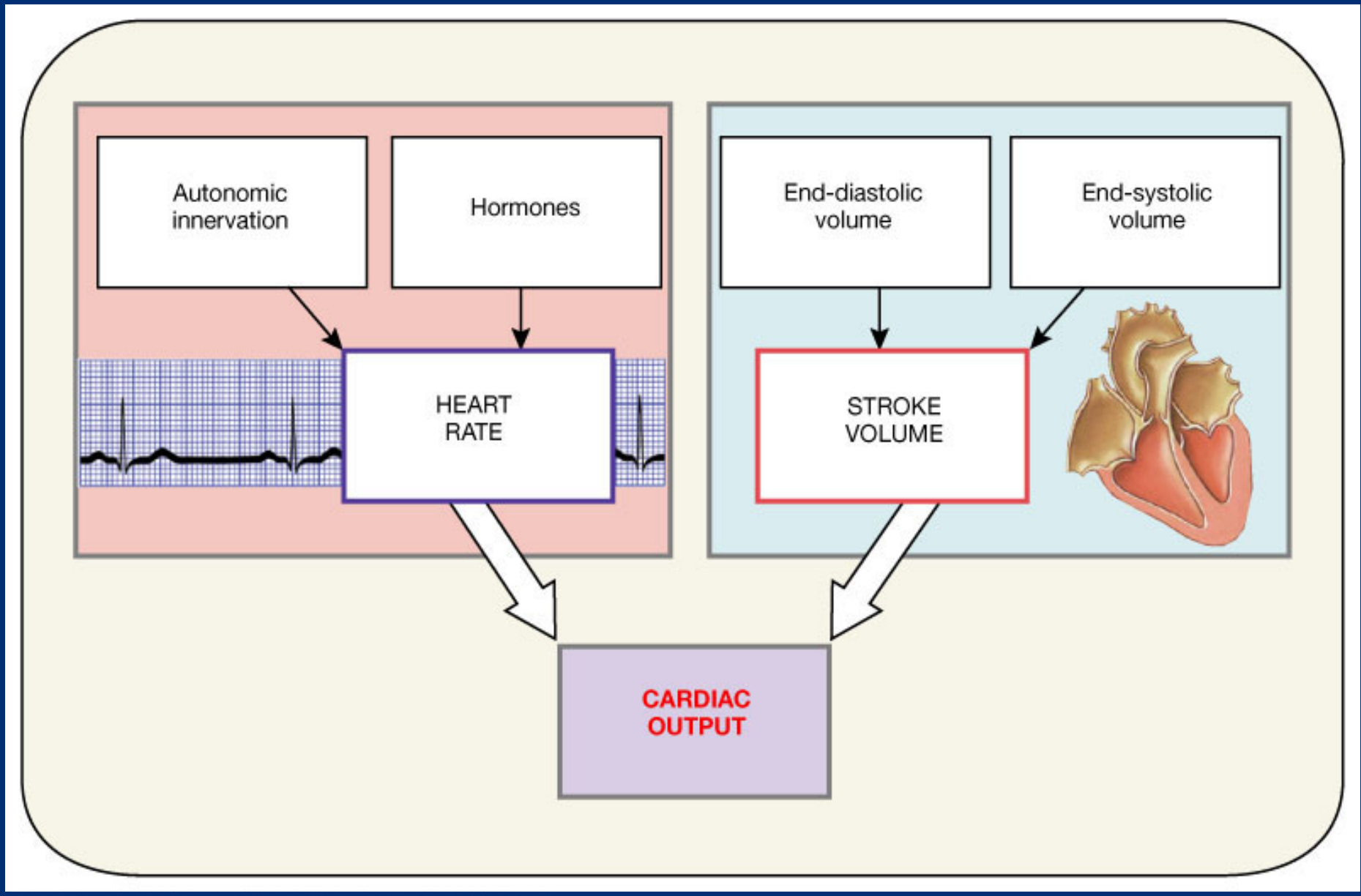
Adjusts heart rate in response to venous return

Stretch receptors in right atrium trigger increase in heart rate through increased sympathetic activity.

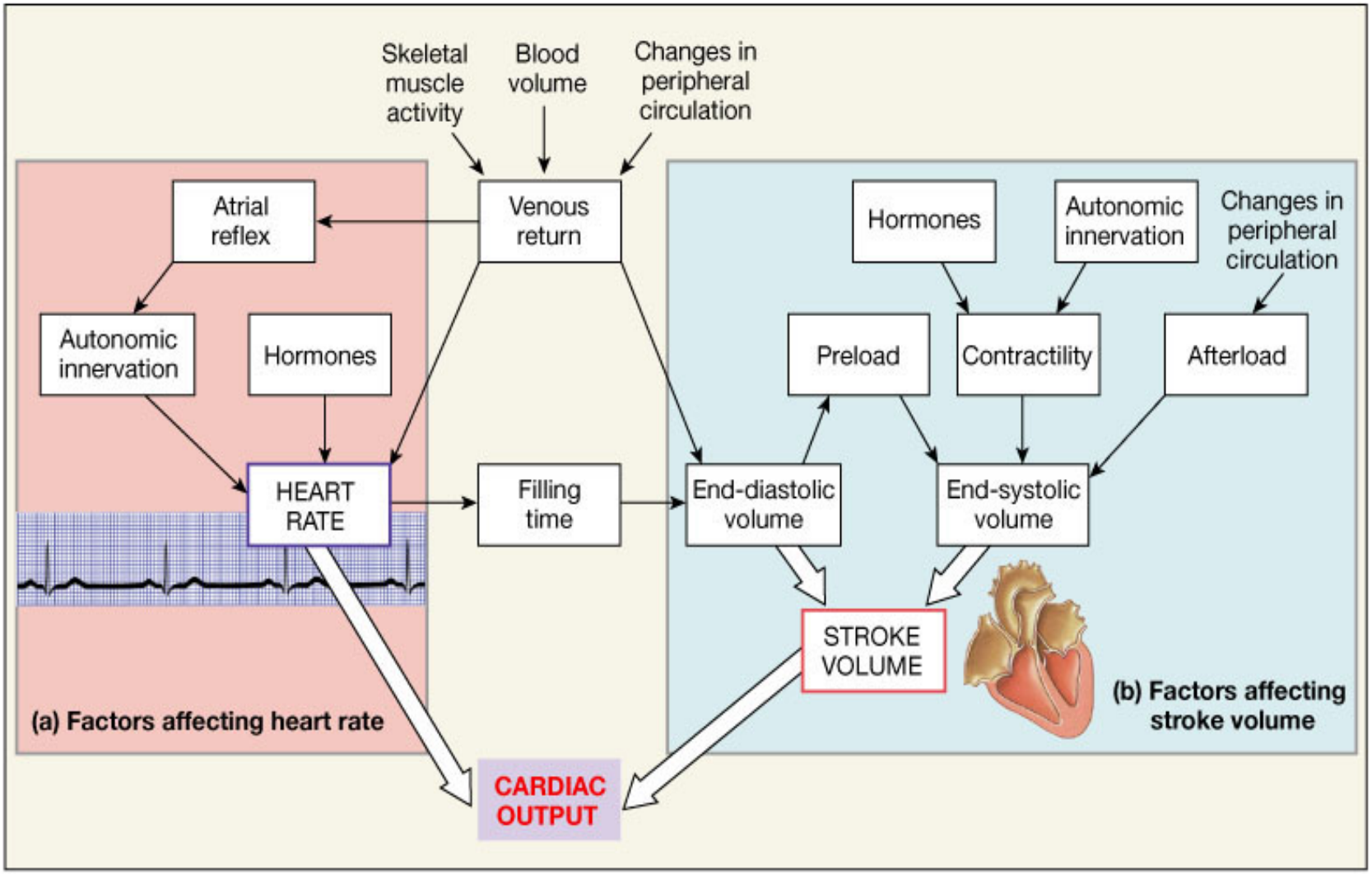
Regulation of Heart Rate

- Decreased heart rate by:
  - Parasympathetic nervous system
  - High blood pressure or blood volume

Factors Affecting Cardiac Output



Summary of the Factors Affecting Cardiac Output



Cardiac index

- It relates the cardiac output to body surface area. Thus relating heart performance to the size of the individual.

- The unit of measurement is liter per minute per square meter of body surface area (L/min/m^2).

Measurement Of C.O.

The Direct Fick's Method:

It states that, the amount or volume of any substance taken up by an organ or by the whole body is equal to:

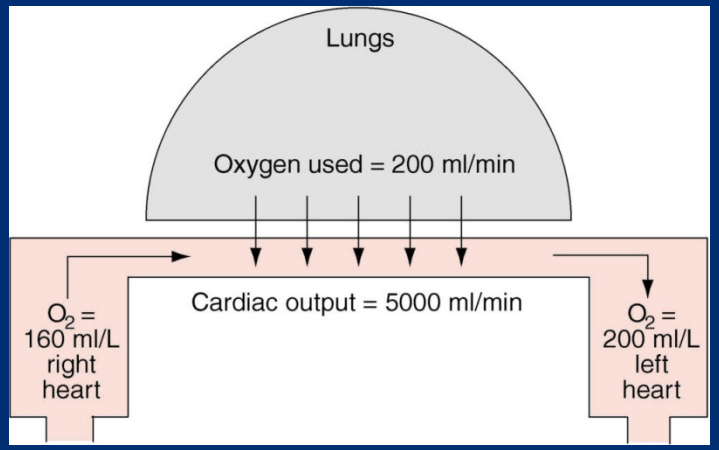
(The arterial level of the substance – the venous level) X blood flow.

$$\text{Blood flow} = \frac{\text{Amount}}{\text{(Arterial level – Venous level)}}$$

Methods for measuring cardiac output

- Cardiac output can be *measured* using the Fick principle, whose fundamental assumption is that, in the steady state, the cardiac output of the left and right ventricles is equal.
- The Fick principle states that in the steady state, the rate of O2 consumption by the body must equal the amount of O2 leaving the lungs in the pulmonary vein minus the amount of O2 returning to the lungs in the pulmonary artery.
- Total O2 consumption or the rate of oxygen absorption by the lungs can be measured by the rate of disappearance of oxygen from respired air, using any oxygen meter.
- The amount of O2 in the pulmonary veins is pulmonary blood flow multiplied by the O2 content of pulmonary venous blood. Likewise, the amount of O2 returned to the lungs via the pulmonary artery is pulmonary blood flow multiplied by the O2 content of pulmonary arterial blood.
- O2 consumption = cardiac output × [O2] pulmonary vein - cardiac output × [O2] pulmonary artery

- **Cardiac output = O2 absorbed by the lungs per minute/arteriovenous O2 difference**



For further readings and diagrams:

Textbook of Medical Physiology by Guyton & Hall

Chapter 17 (Cardiac Output)