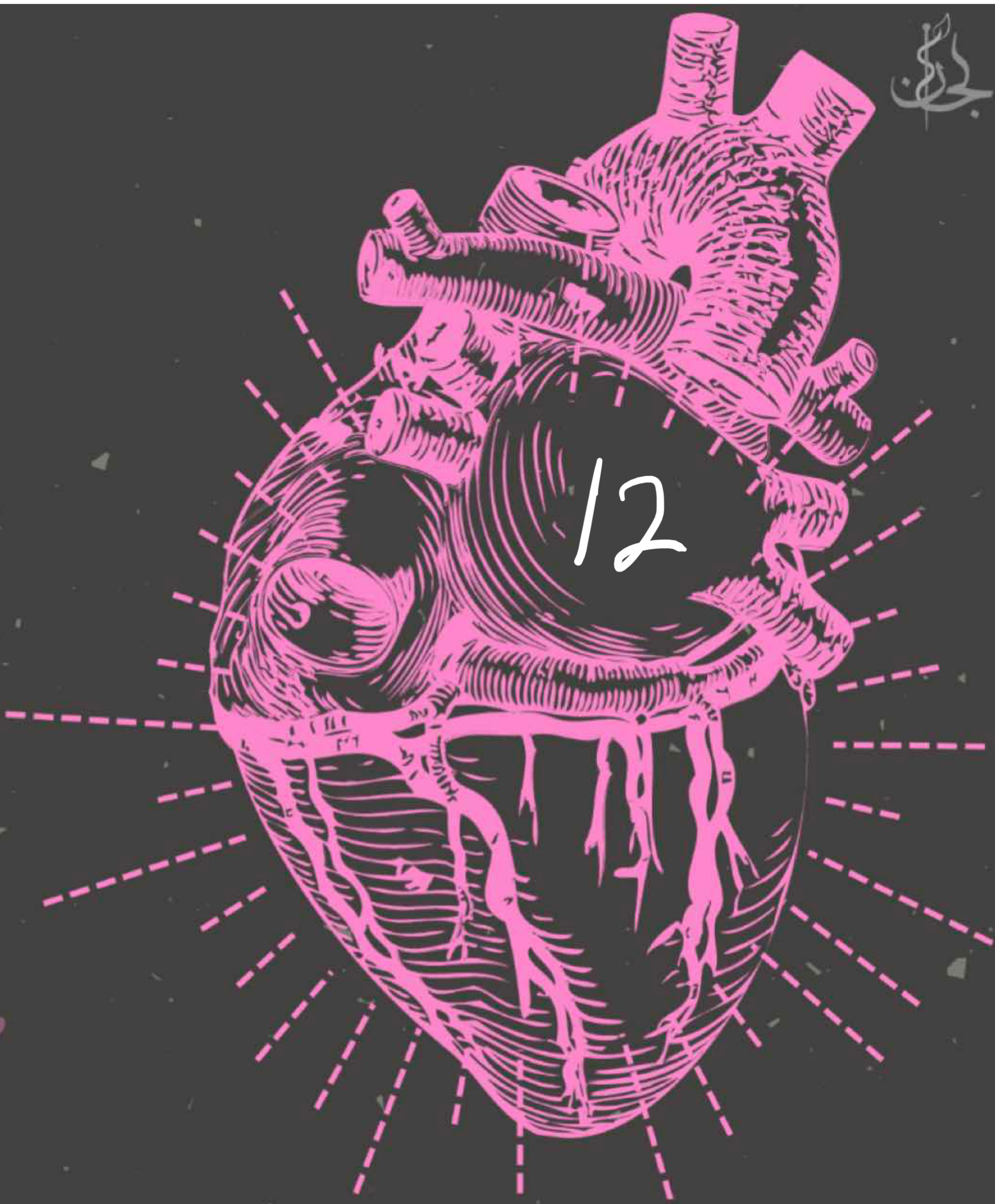
CVS



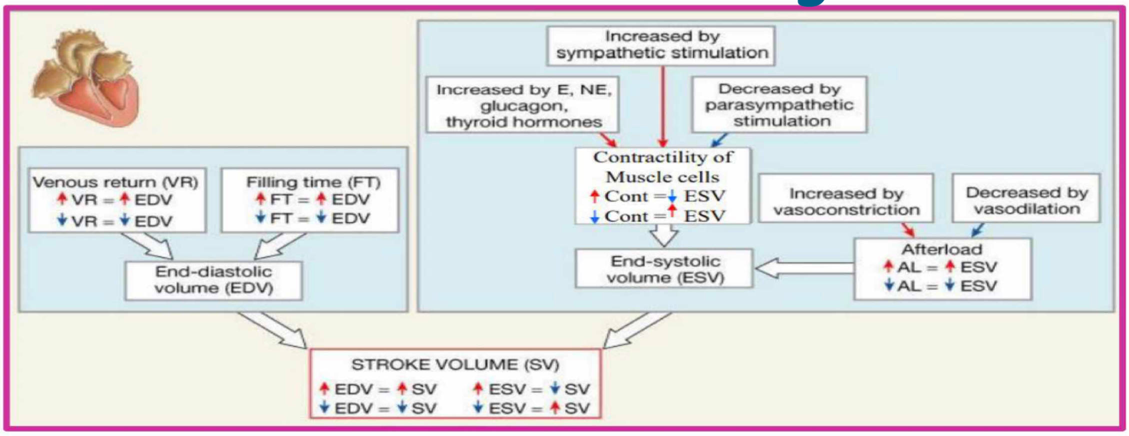
PHYSIOLOGY

WRITER: 018 sheets

CORRECTOR: Sawsan alqeam

DOCTOR: Faisal mohammad.

Summary



SV= EDV-ESV → ↑SV=↑EDV-↓ESV

EDV : volume at the end of diastole (at the end of filling phase, how much did we fill?)

EDV increases :

1. ↑Venous return
2. ↑Filling time

ESV: volume at the end of systole (after end of contraction, how much blood is left in ventricle?)

ESV increases:

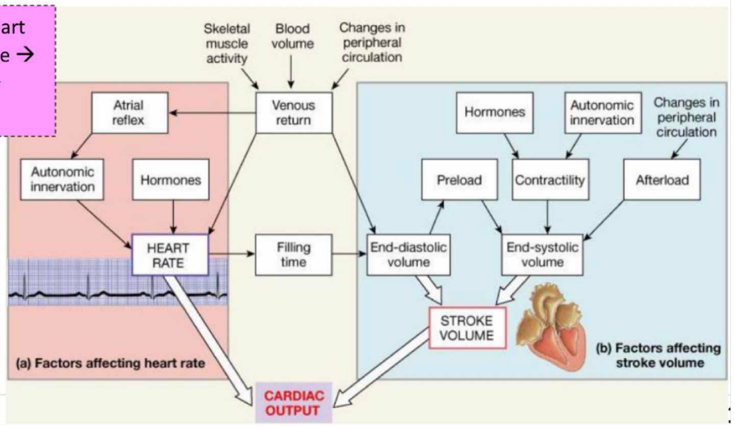
1. By ↓ in contractility (lower amount of blood is pumped→ higher blood is left in ventricle at end of systole)
2. Vasoconstriction in aorta (higher aortic pressure =↑afterload → reduced ability of vent. To pump blood so more blood left in vent).

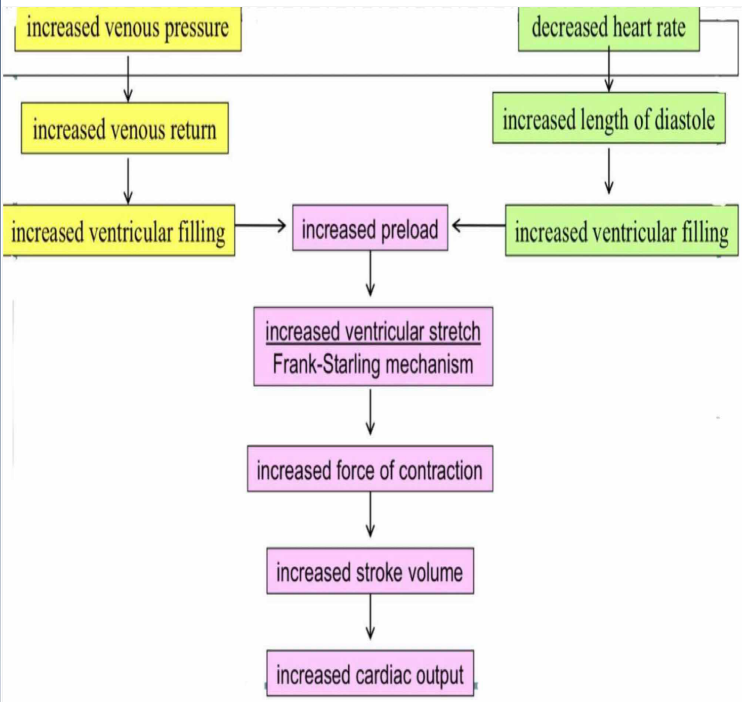
Atrial reflex increases heart rate → reduce filling time → reduce stroke volume → reduce CO

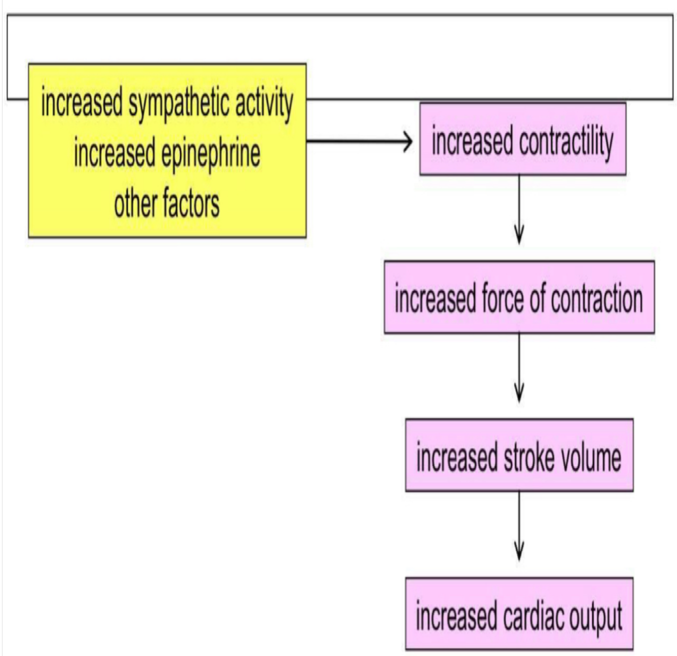
↑Venous return:

1. ↑Skeletal muscle contraction ? push blood faster
2. Vasodilation
3. High blood volume

↑Venous return will increase EDV





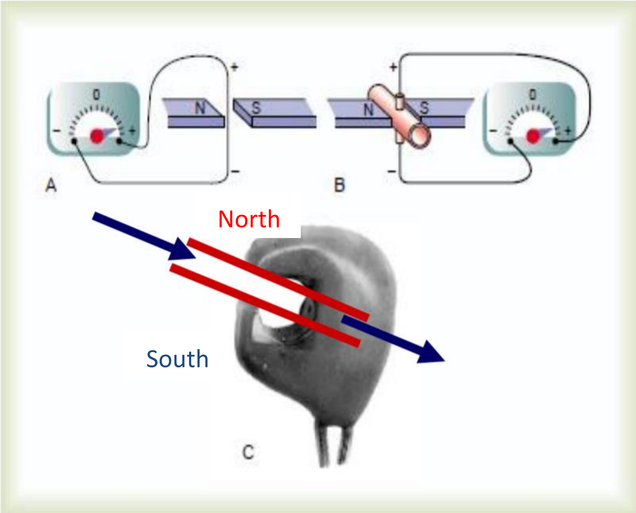


Cardiac Output Measurements

*We can measure the CO by either **Direct methods** or **Indirect methods**

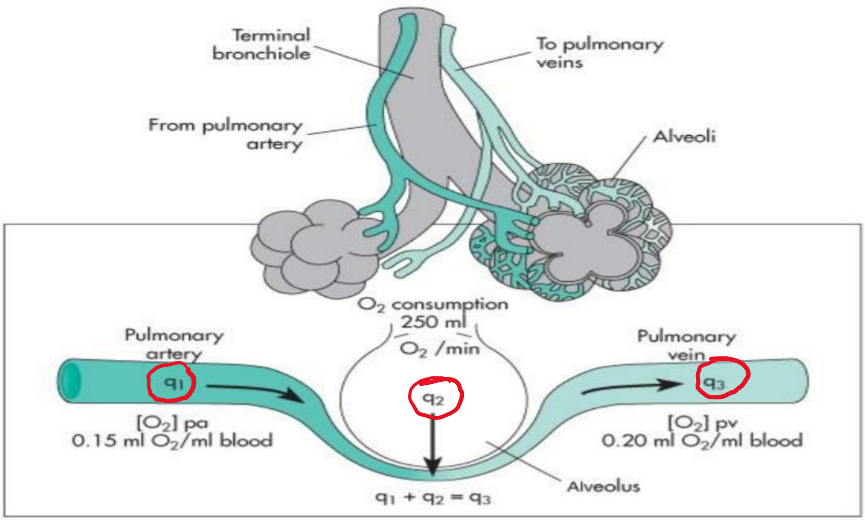
1-Direct method: we make the aorta bleed and collect the blood but it's not practical and not used

2-Indirect methods:



A- Electromagnetic flowmeter: We have two poles of a magnet (north and south). When a charged flow runs between the two poles, a current is thus formed and can be calibrated up by a galvanometer. Because blood is full of electrolytes, it is a charged flow, and the current that would be formed between the poles of the magnet is proportional to the flow. If we measure this flow per min, we can calculate the cardiac output. This method can be used around any artery, and many times. It is usually used in cardiac surgery.

B- Oxygen Fick method:



*The O_2 content of the pulmonary vein **=** the O_2 content of the pulmonary artery **+** the O_2 that has been taken up from the lung.

*The amount of oxygen that enters the lung per min. through the pulmonary artery (q1) = cardiac output × oxygen concentration in the systemic **venous** blood q2= the amount of oxygen taken by the lungs from air through alveoli.

q3= the amount of oxygen that enters the pulmonary veins: This equals the cardiac output × **arterial** oxygen concentration.

Remember that the pulmonary vein carries arterial blood, while the pulmonary artery carries venous blood

---

Now that we know that q3 = q1 + q2:

$$CO \times arterial\ O2\ conc. = CO \times venous\ O2\ conc. + oxygen\ uptake$$

$$\text{Oxygen uptake} = \text{CO} \times \{C_{AO2}\text{-}C_{VO2}\} \rightarrow \text{CO} = \frac{Oxygen\ uptake}{\{C_{AO2} - C_{VO2}\}}$$

To sum things up.. Cardiac output = (oxygen consumption in 1min) / (arterial concentration of oxygen – venous concentration of O2). **Pay attention to the units ^^**

Some Q&As

How to find the oxygen consumption?
- We measure it using a spirometer. You let the patient breathe and you measure concentration of inspired O_2 after one or two minutes.

How to find the arterial and venous concentrations of oxygen?
- All arteries have the same concentration of oxygen because the exchange happens only at the level of the capillaries. That's why you can take a sample from any artery to measure the concentration of oxygen in arterial blood.
However..
We can't take venous sample from any vein because the concentration of oxygen differs according to the metabolic needs. So we put a special catheter called **Swan-Ganz** catheter in the pulmonary artery or the right ventricle (using the cubital vein). This blood found there is called **central venous blood**; as if we mix all venous blood and take the sample.

Test your understanding:

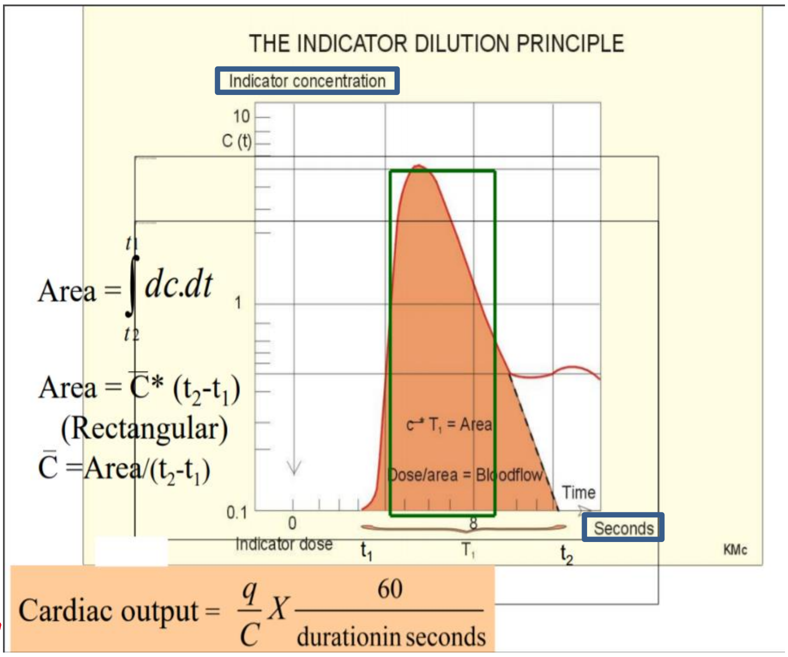
O_2 Fick Problem

- If pulmonary vein O_2 content = 200 ml O_2/L blood
- Pulmonary artery O_2 content = 160 ml O_2 /L blood
- Lungs add 400 ml O_2 /min
- What is cardiac output?
- Answer: 400/(200-160) =10 L/min

Again, pay attention to the units (mL, L, etc)

Some Qs may require conversions.

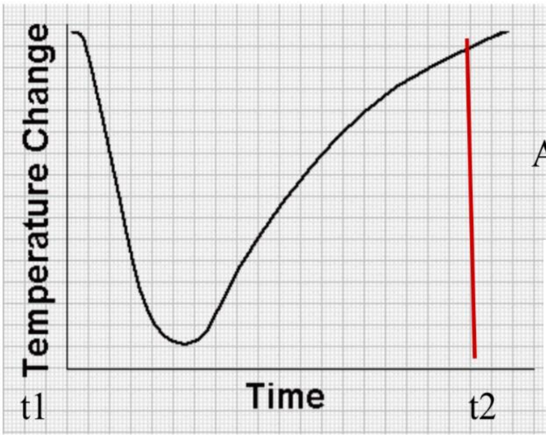
C- Indicator Dilution principle:



We use an indicator that is non-toxic, distributed well and colorful. E.g. ***Cardiogreen.*** We inject a certain amount of this dye (call it q) in the right ventricle (using Swan Ganz catheter we mentioned before). **Briefly:** we draw this curve and we calculate the area (either by integration or by rectangles), dividing it by time duration to get the mean concentration (C). Using this equation we can get the cardiac output.

D- Thermodilution principle:

We inject cold saline with a known temperature and volume (again using Swan Ganz catheter). **Notice that this special catheter has a thermistor that measures temperature.**



$$\text{AREA} = \int_{t1}^{t2} dT.dt$$

$$\frac{Area \times 60}{Tavg \times duration}$$

Now using a special computer program we can calculate the cardiac output through integrating temperature changes over time. (or we can use an equation similar to the last method's)

The advantage of this method is that you can use it multiple times to have multiple readings and take the average