

(XI.) Digital model of aortic function

(XVI.) Blood flow in veins

Physiology – practicals

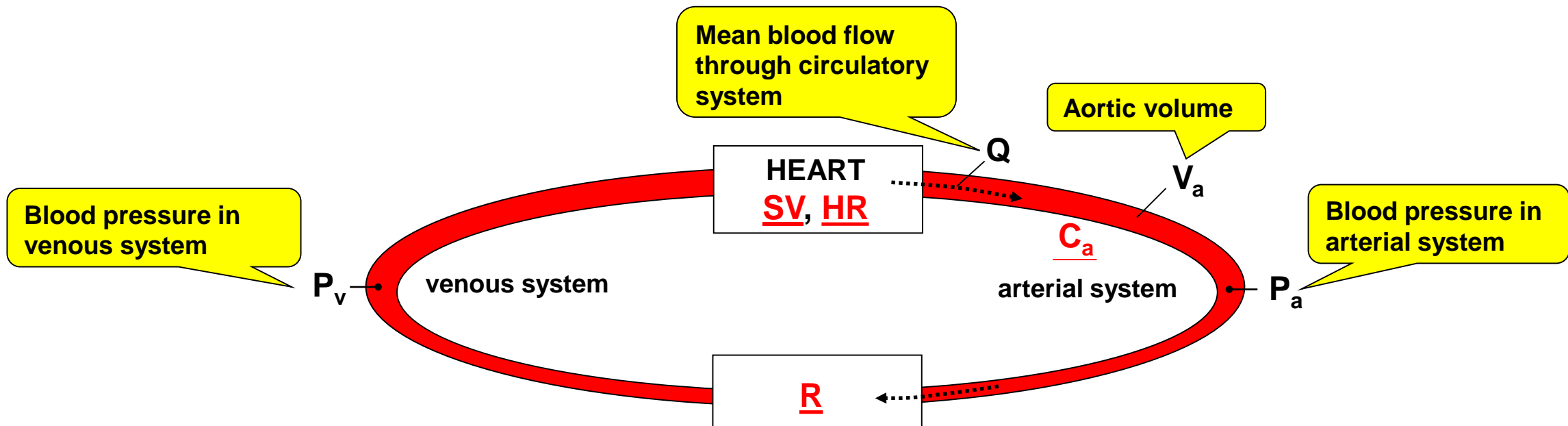
Definitions of key words and symbols

Stroke volume (SV) – volume of blood ejected from the left ventricle to the aorta during one contraction

Heart rate (HR) – number of heart contractions per 1 minute

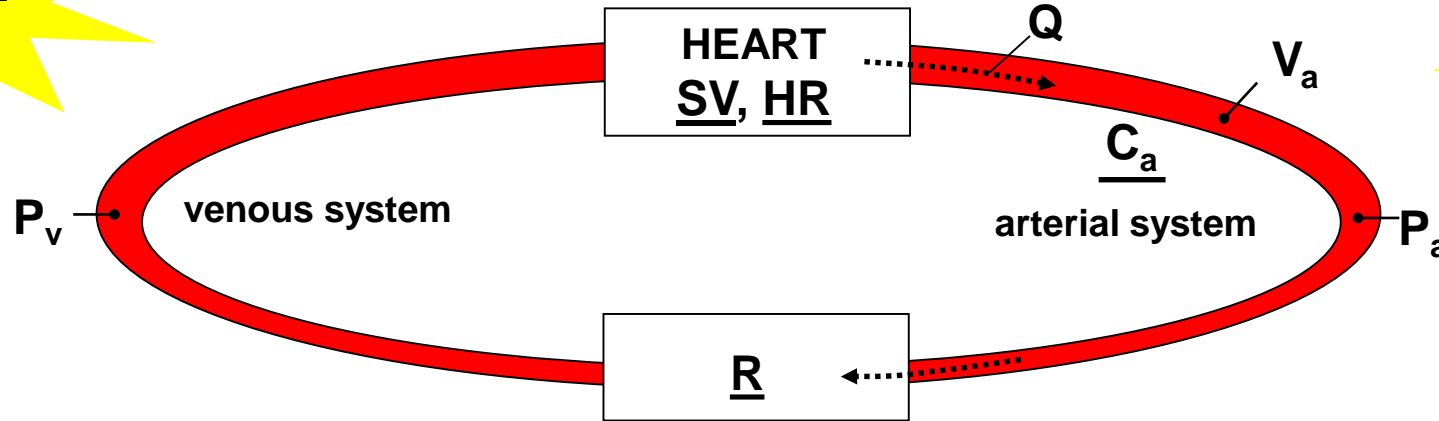
Peripheral vascular resistance (R) – resistance of small arteries (mainly arterioles and capillaries)

Compliance of aorta (C_a) – ability of aorta to change its volume according to changes of blood pressure



Arterial blood pressure in case of changing circulatory parameters and cardiac output

$$Q = \frac{P_a - P_v}{R}$$



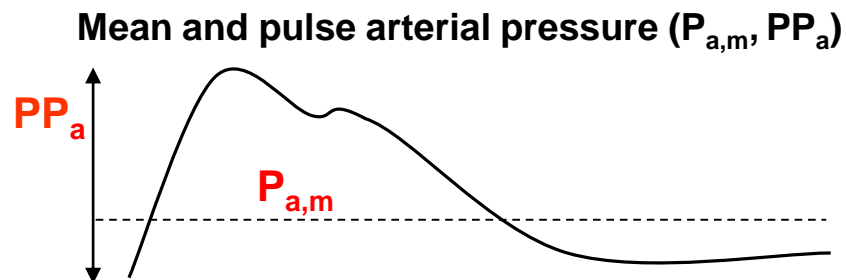
$$C_a = \frac{\Delta V_a}{\Delta P_a}$$

$$P_{a,m} - P_{v,m} = Q \cdot R$$

$$\Delta V_a \cong SV$$

$$P_{a,m} = SV \cdot HR \cdot R + P_{v,m}$$

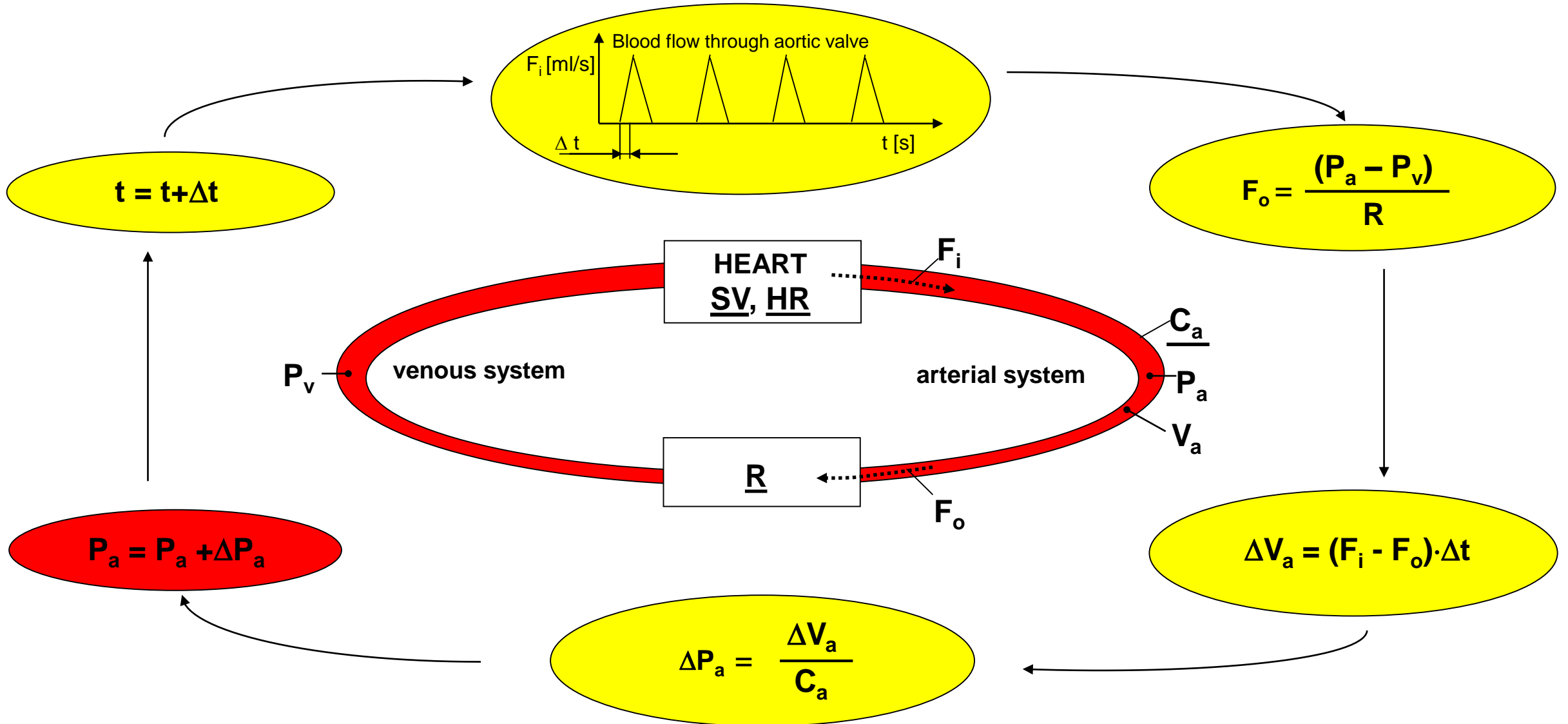
$$P_{a,m} \cong SV \cdot HR \cdot R$$



$$PP_a \cong \frac{SV}{C_a}$$

Model of aortic function

Calculation of P_a

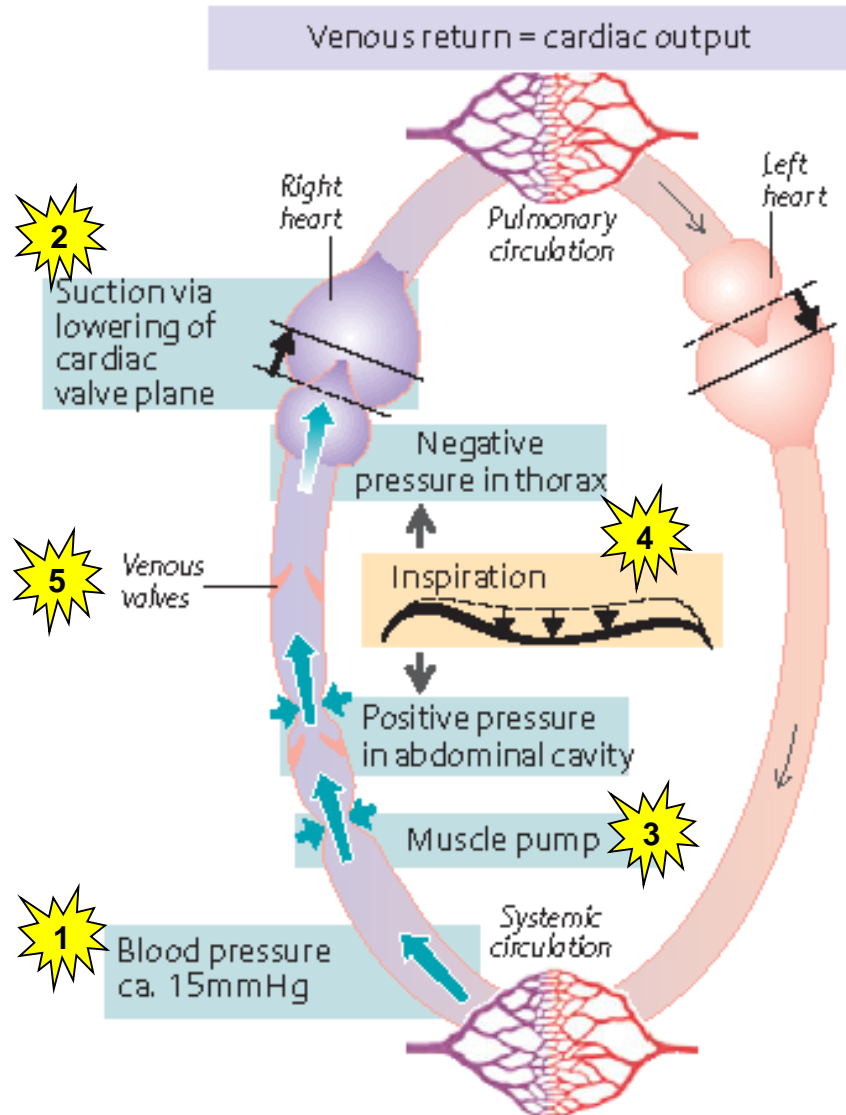


Modeled situations

- **Physiological conditions:** $SV=70$ ml, $HR=75/\text{min}$, $R=1$ mmHg·s/l, $C=1.2$ ml/mmHg
- **Changes of SV – increase:** hyperhydration – rapid administration of i.v. infusion, intake of large amount of water in short time; **decrease:** dehydration, loss of blood (haemorrhage)
- **Changes of HR – increase:** activation of sympathetic nervous system – stress, physical activity; **decrease:** increase of vagal tone, adaptation of heart in sportsmen (athletic heart)
- **Changes of R – increase:** predominance of vasoconstriction – e.g. in cold environment; **decrease:** predominance of vasodilation – sauna, distributive shock (anaphylaxis, adrenal crisis)
- **Changes of C – higher values:** predominance of elastic fibers – in children and young people; **lower values:** elastic fibers degeneration – in elderly people, atherosclerosis (leads to isolated systolic hypertension – systolic blood pressure is higher than normal, diastolic blood pressure is predominantly at normal level)

- **Reaction to physical activity:** increase of SV to 100 ml, increase of HR to 150/min, decrease of R to 0.6 mmHg·s/l
- **Simulation of hypertension:** increase of SV and HR by 20% – essential hypertension; increase of R by 40% at physiological resting values of SV and HR – fully developed hypertension
- **Simulation of cardiac arrest:** after stabilization of values of blood pressure, decrease of SV to 0 ml at different values of HR, C and R

Mechanisms of venous return



1. **Pressure gradient between venous system and right atrium** („a force acting from behind“ – *vis a tergo*)

2. **Suction effect of systole** („a force acting from in front“ – *vis a fronte*)

3. **Skeletal muscle contractions – muscle pump**

4. **Suction effect of inspiration – increased intraabdominal pressure and decreased intrathoracic pressure**

5. **Venous valves**