(VIII.) Blood pressure in man
(IX.) Non-invasive methods of blood pressure measurement

Physiology II - practice

Arterial blood pressure curve

Blood pressure (BP): pressure on vascular wall (continual variable)

Mean arterial pressure (MAP) : mean value of blood pressure in the inter-beat interval (IBI)

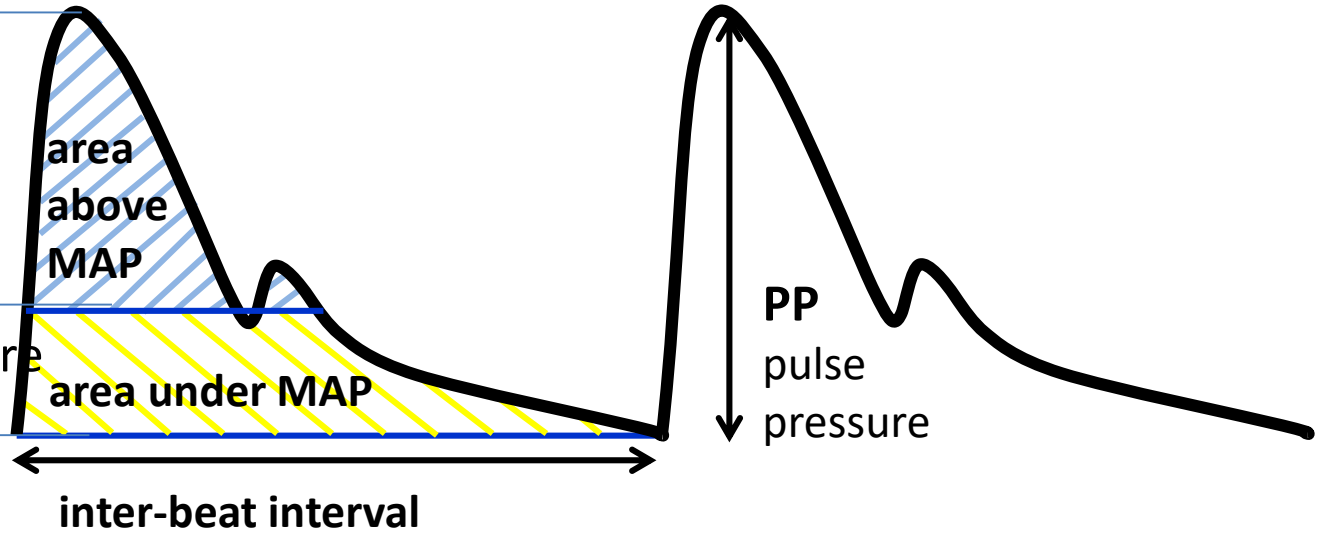
- **area under MAP = area above MAP**
- **aproximation: MAP≈ DBP + 1/3 PP** **(PP = SBP – DBP)**

Definition:
SBP - maximum of BP during ejection phase of cardiac cycle
DBP – minimum of BP during filling phase of cardiac cycle
Attention: Values of SBP and DBP varies in different parts of cardiovascular system

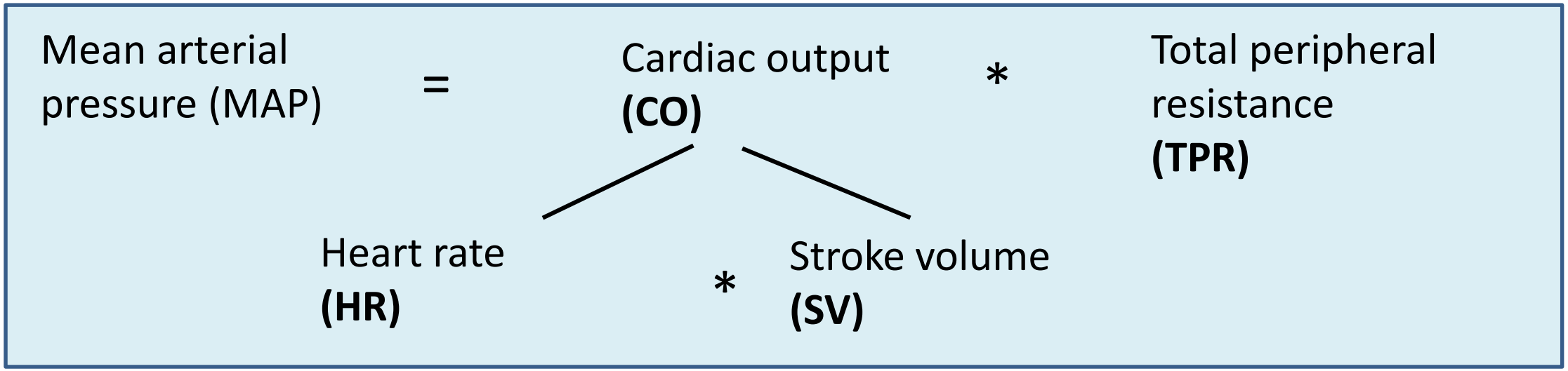
SBP
Systolic blood pressure (maximum of BP on pulse curve recorded by sphygmography)

MAP
Mean arterial pressure

DBP
Diastolic blood pressure (minimum of BP on pulse curve recorded by sphygmography)



MAP is a function of cardiac output and total peripheral resistance



- SBP is given mainly by CO
- DBP is given mainly by TPR

Blood pressure regulation

- **Short-term** – neural control, mainly baroreflex
- **Medium-term** – hormonal regulation, renin-angiotensin-aldosteron system (RAAS)
- **Long-term** – hormonal regulation of blood volume

Short-term BP control: Baroreflex

Autonomic nervous system:

sympathetic nerves (↑ BP, HR, SV a TPR) versus ***parasympathetic nerves*** (↓BP, HR, SV a TPR)

Baroreflex: regulation of BP via changes of HR and TPR

baroreceptors – sinus caroticus + sinus aorticus

afferentation: n. vagus, n. glossopharyngeus

- **Cardiac branch of baroreflex:**

  efferentation: n. vagus - SA node

  sympathetic efferentation: change of HR and cardiac contractility

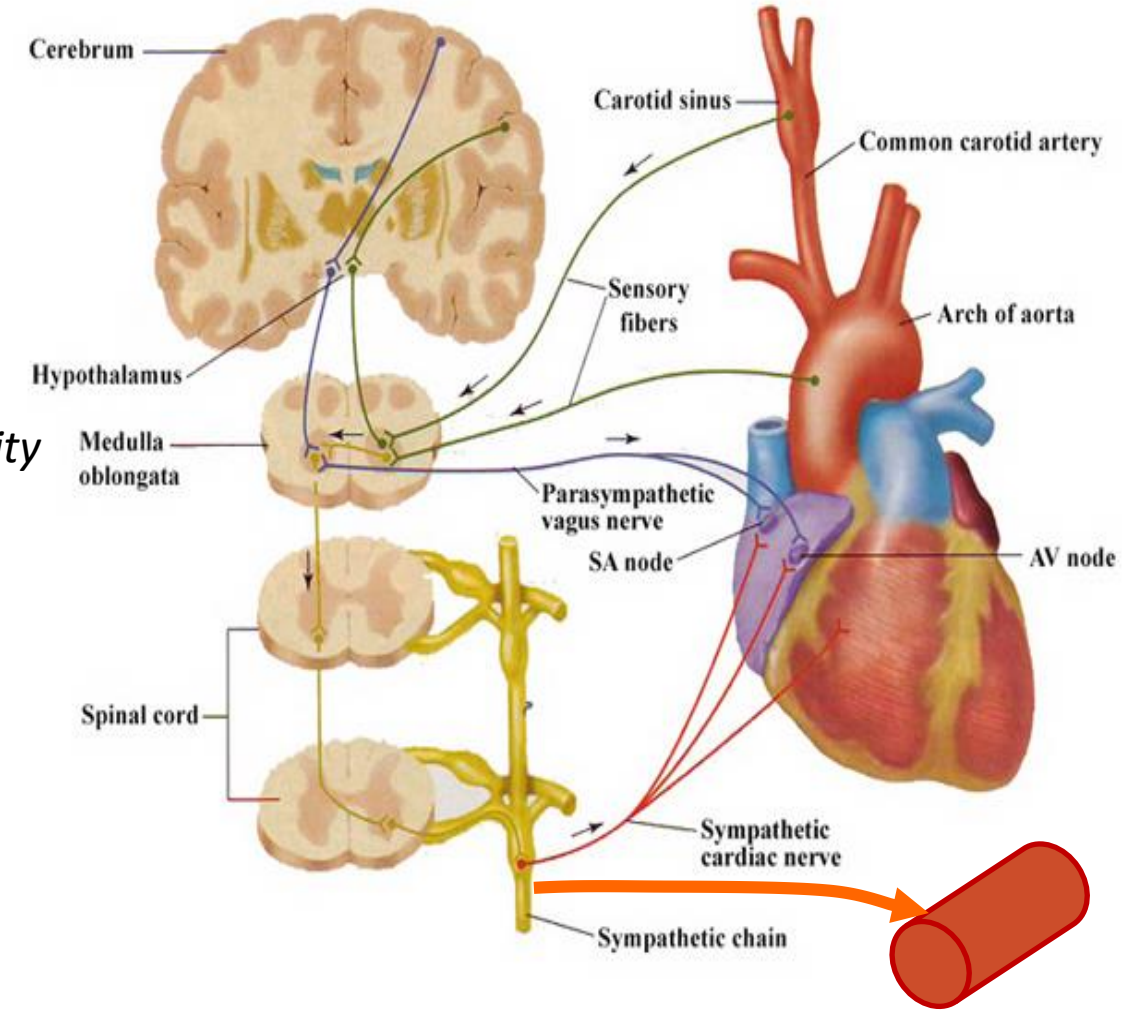
  ↑BP →↓HR and vice versa

- **Peripheral branch of baroreflex:**

  efferentation: sympathetic vascular innervation

  ↑BP →↓TPR and vice versa

  (vasoconstriction, venoconstriction)



Blood pressure changes

Short-term influences

- blood volume - influence to SV (bleeding, dehydration)
- external pressure to the vessels - intrathoracal a intraabdominal pressure (cough, defecation, childbirth, artificial ventilation)
- position – orthostasis: higher DBP (↑TPR) a lower STK (↓venous return→ ↓heart filling → Starling principle→ ↓cardiac contraction → ↓SV)
- CNS – emotions, mental stress,…
- physical load – BP changes depend on intensity, duration and type of exercise
- heat (↓ TPR), cold (↑ TPR)
- alcohol, medicaments,…

Long-term influences

- age (the fastest changes during childhood and adolescence)
- sex (usually in men: higher BP)

Methods of the arterial blood pressure measurement

In practicals:

Palpatory
(sphygmomanometer)

Auscultatory
(sphygmomanometer, stethoscope)

Oscillometric

Another approaches:

24-hour blood pressure monitoring

Photoplethysmografic (volume-clamp method, Peňáz)

Laminar / turbulent flow, Korotkoff sounds

$$Re = \frac{v \cdot S \cdot \rho}{\eta}$$

laminar flow Re < 2000
turbulent flow Re > 3000

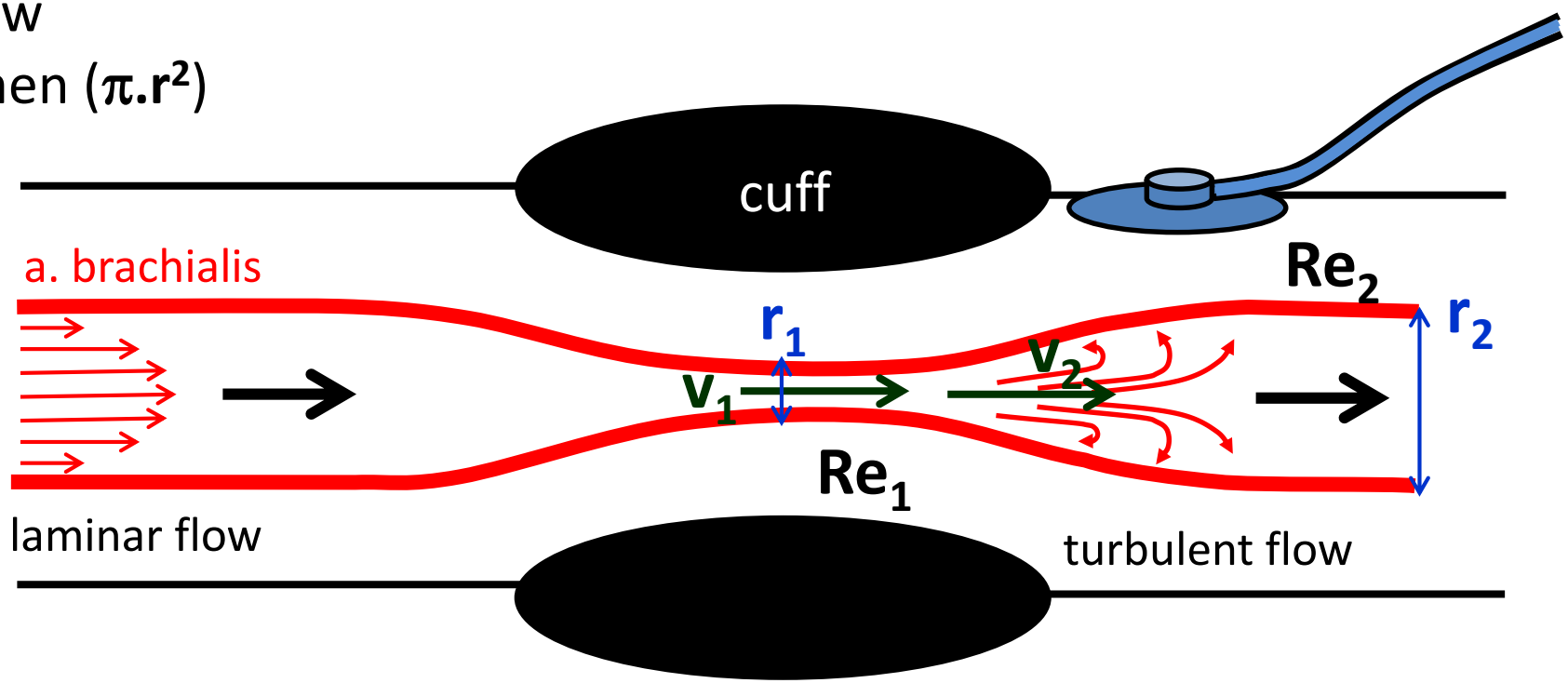
Reynolds number Re: predicts the transition from laminar to turbulent of flow

v: velocity of blood flow

S: area of vascular lumen ($\pi.r^2$)

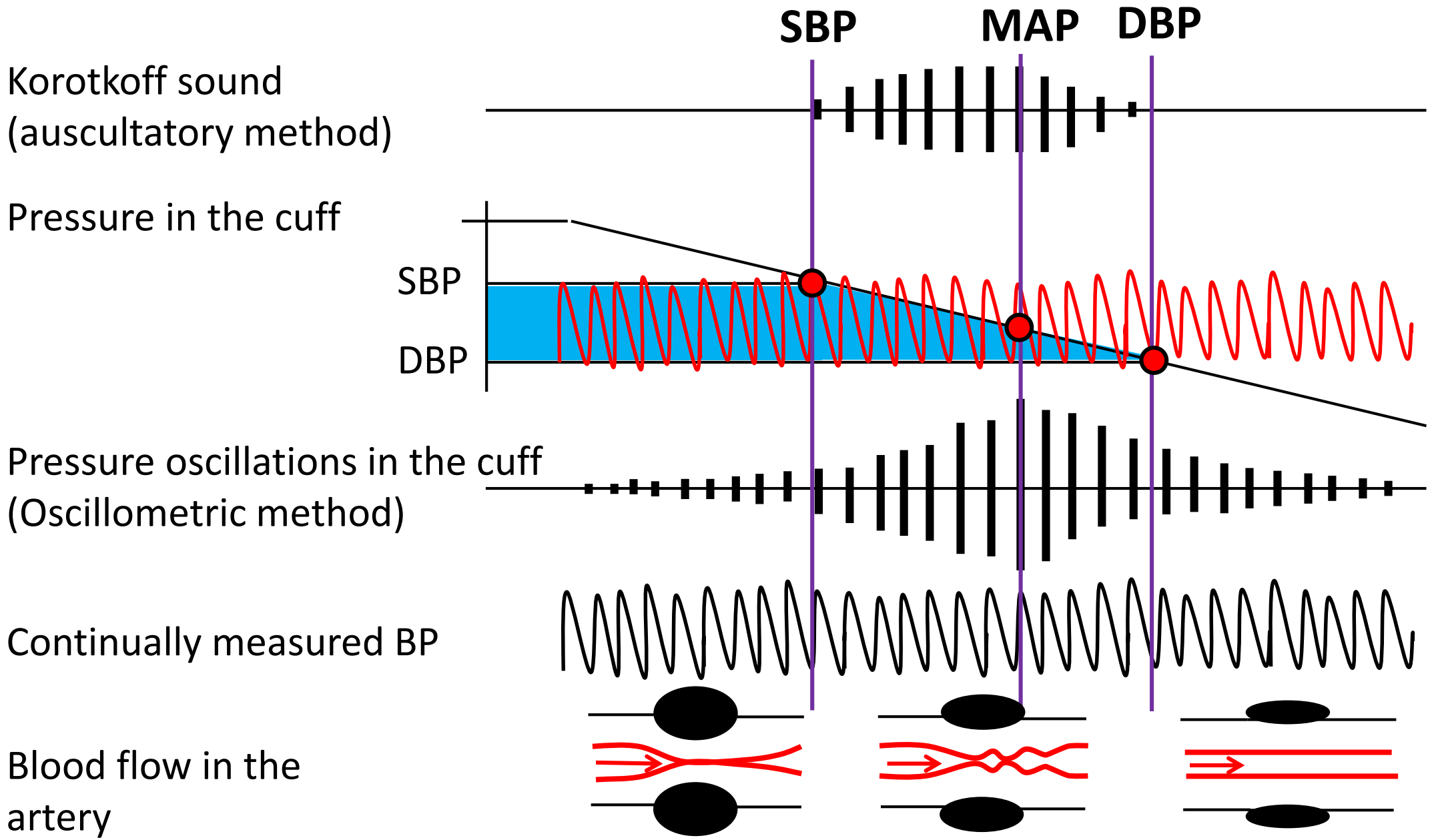
ρ: density of blood

η: viskosity of blood
(higher in anaemia)



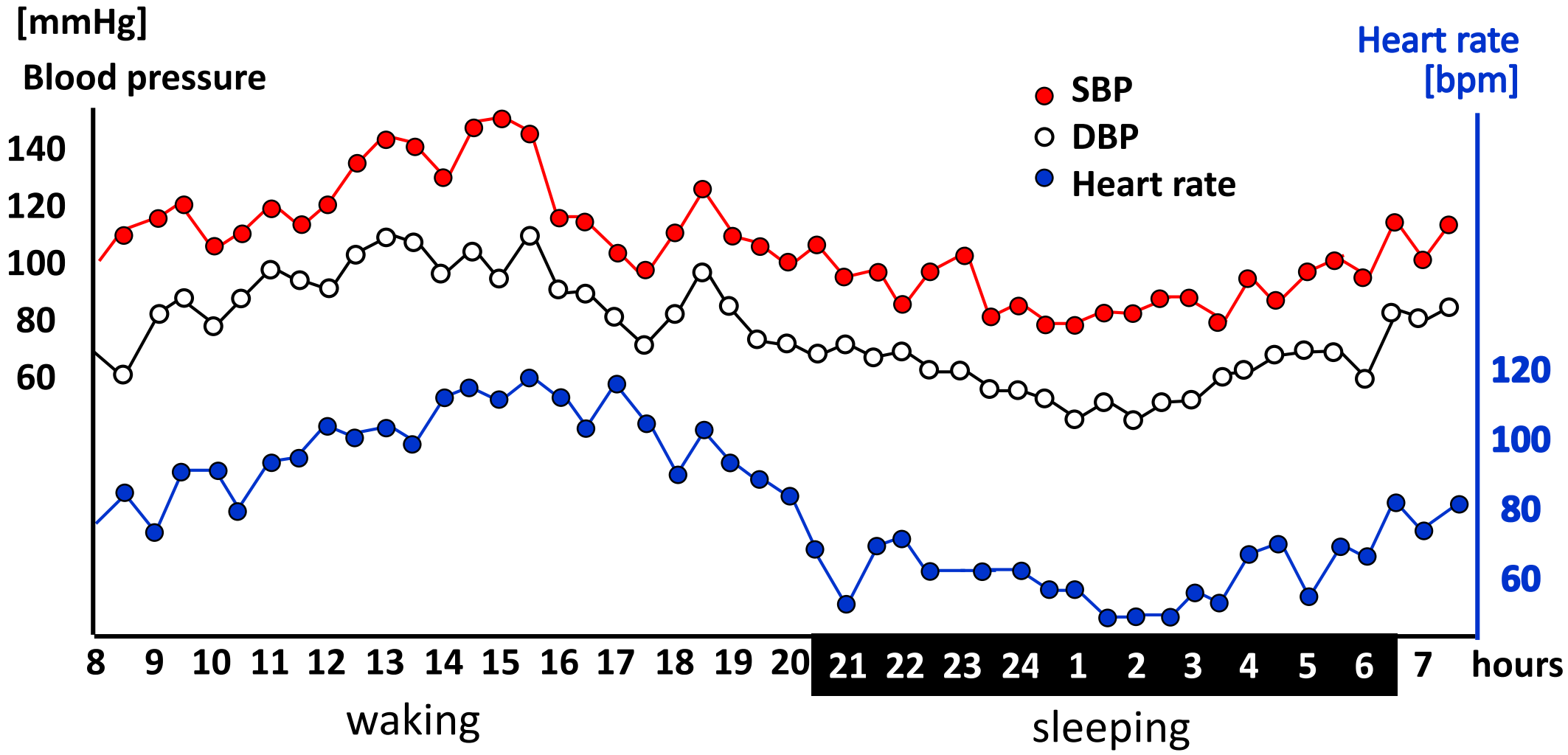
closely behind narrowing of the artery: $S_1 < S_2$ a $v_1 \approx v_2$ → $Re_1 < Re_2$ → turbulent flow

Principles of blood pressure measurement



24-hour blood pressure monitoring

BP decrease during night: 10 - 15%



During BP measurement following rules must be observed

- Patient is sitting for a few minutes before the measurement.
- Only validated apparatus must be used.
- Perform at least two measurements in the course of 1–2 minutes.
- Use cuff of standard size (12–13 cm width and 35 cm length); however smaller and bigger cuffs must be available for patients with smaller or bigger size of arm, respectively.
- Cuff must be always at the level of heart of examined person.
- Pressure in the cuff must be decreased slowly: 2mmHg/s.

methods	advantages	disadvantages	measured value
auscultatory	• exact estimation of SBP/DBP • easy, it doesn´t require electricity	• subjective, experience is necessary • SBP/DBP from different IBI	SBP and DBP
oscillometric	• exact estimation of MAP • automatic, fast • BP can be measured by layman, cheap (home measurement)	• DBP/SBP is calculated (dependence on model, influence on shape of pulse wave) • SBP/DBP from different IBI • false values during arrhytmias	MAP, sometimes SBP (it depends on device)
24 – hour BP monitoring	• BP record from whole day • diagnosis of white-coat hypertension	• disruptive influence of measuring (during sleeping) • SBP/DBP from different IBI	BP is measured each 15 – 60 min
photople-thysmographic (Peňáz)	• continual BP record • possibility of beat-to beat SBP/DBP calculation (BP variability analysis)	• measuring on the finger, brachial BP recalculating • expensive device	continual BP record

Diagnosis of hypertension

	blood pressure	SBP [mmHg]	DBP [mmHg]	possible complications
normal	optimal	<120	<80	
	normal	120 – 129	80 – 84	
	high normal	130 – 139	85 – 90	
hyper-tension	1st stage	140 – 159	90 – 99	without organ changes
	2nd stage	160 – 179	100 – 109	hypertrophy of L ventricle, proteinuria, angiopathy, ...
	3rd stage	> 180	> 110	morphological and functional changes of some organs, retinopathy, heart and renal insufficiency, ischemia of CNS, bleeding in CNS

- **isolated systolic hypertension:** SBP> 140 and DBP <90
- high normal BP – annual monitoring recomended
- home measurement to exclude white coat hypertension
- **hypertension is diagnosed when:**
- average BP from 4 – 5 examinations is > 140/90
- BP during a home measurement repeatedly > 135/80
- mean BP from 24-hour monitoring is > 130/80

Changes of blood pressure during exercise

- increase of BP depends on the type, intensity and duration of the load
- sympathetic activation: changes in the cardiovascular system serve to satisfy metabolic needs of working muscle
- impact of exercise on blood pressure
  - increased cardiac output $\rightarrow$ $\uparrow$SBP
  - Redistribution of blood in the body - metabolic vasodilation in muscle (muscle increases blood flow), vasoconstriction in the GIT, skin and kidneys $\rightarrow$ maintaining or slight change in DBP (depending on the extent of the TPR decrease)

- vasoconstriction in the skin is temporary, since thermoregulatory mechanisms dominate
- DBP increases during isometric muscle work (eg. weightlifting)
- after exercise: decrease of BP on the initial or a slightly lower value, the blood flow in the muscle remains elevated until recovery
- Recovery interval is determined by the parasympathetic tone (can be increased training)