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

Physiology - practicals

Arterial blood pressure curve

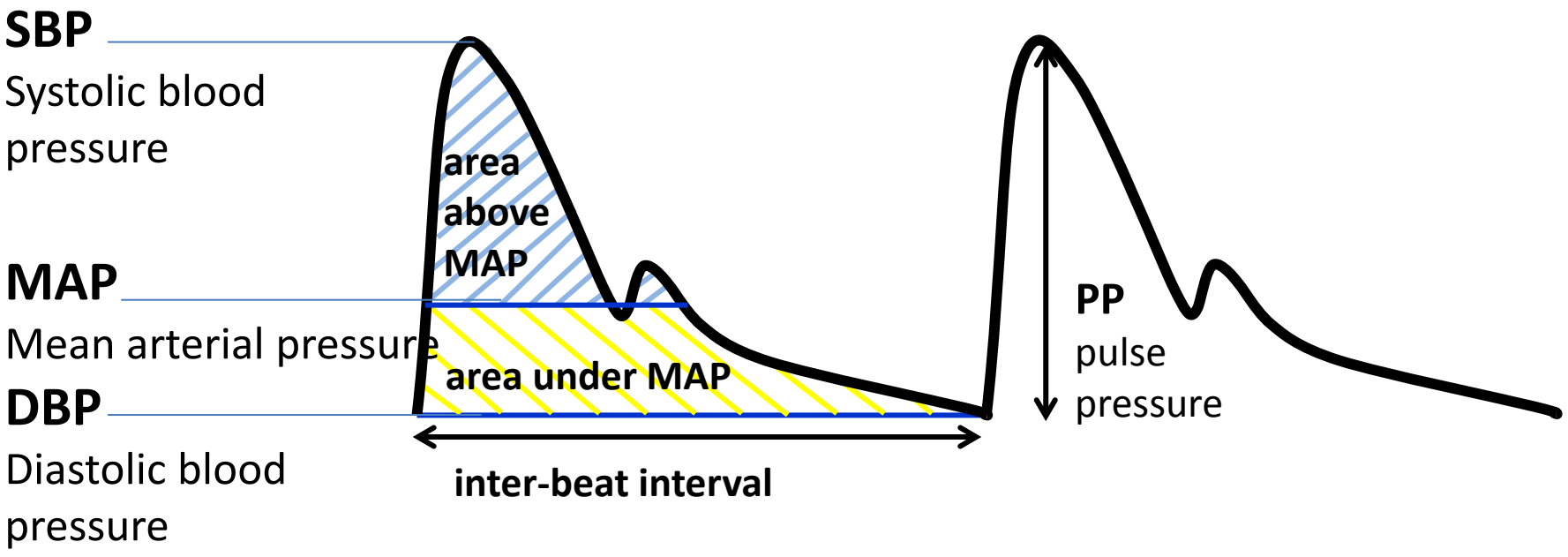
Blood pressure (BP): pressure on vascular vall (continual variable)

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

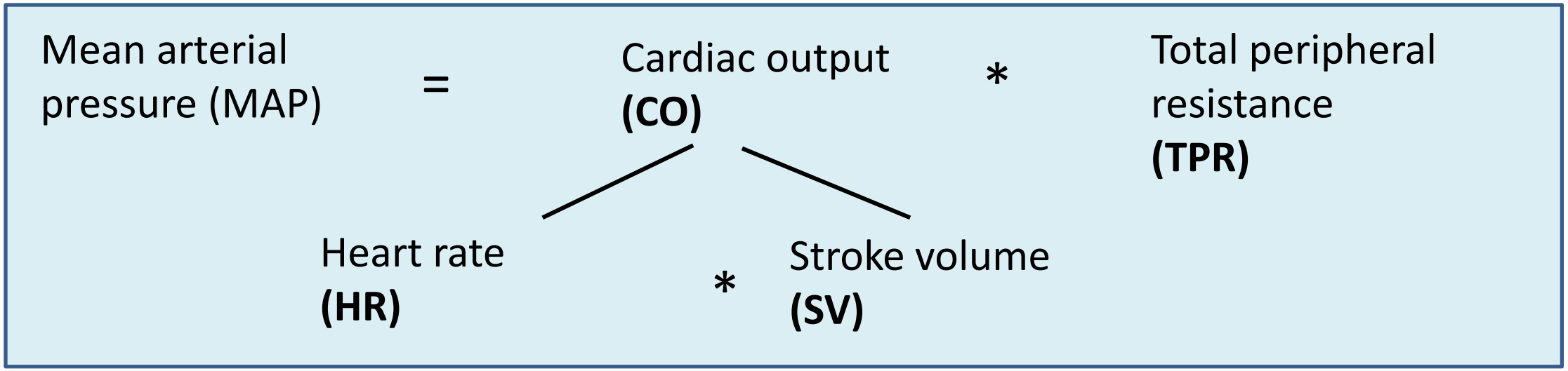
- **area under MAP = area above MAP**
- **aproximation: MAP≈ DBP + 1/3 PP (PP = SBP – DBP)**

Definition:
SBP - maximum of BP in the inter-beat interval
DBP – minimum of BP in the inter-beat interval

Attention: Values of SBP and DBP varies in different parts of cardiovascular system



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 nervou system:

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

Baroreflex: regulation of BP via changes of HR and TPR

baroreceptors – sinus caroticus + aorticus

afferentation: n. vagus, n. glosopharingeus

- **Cardiac branch of baroreflex:**

  efferentation: n. vagus - SA node

  sympathetic efferentation: change of HR and cardiac contractility

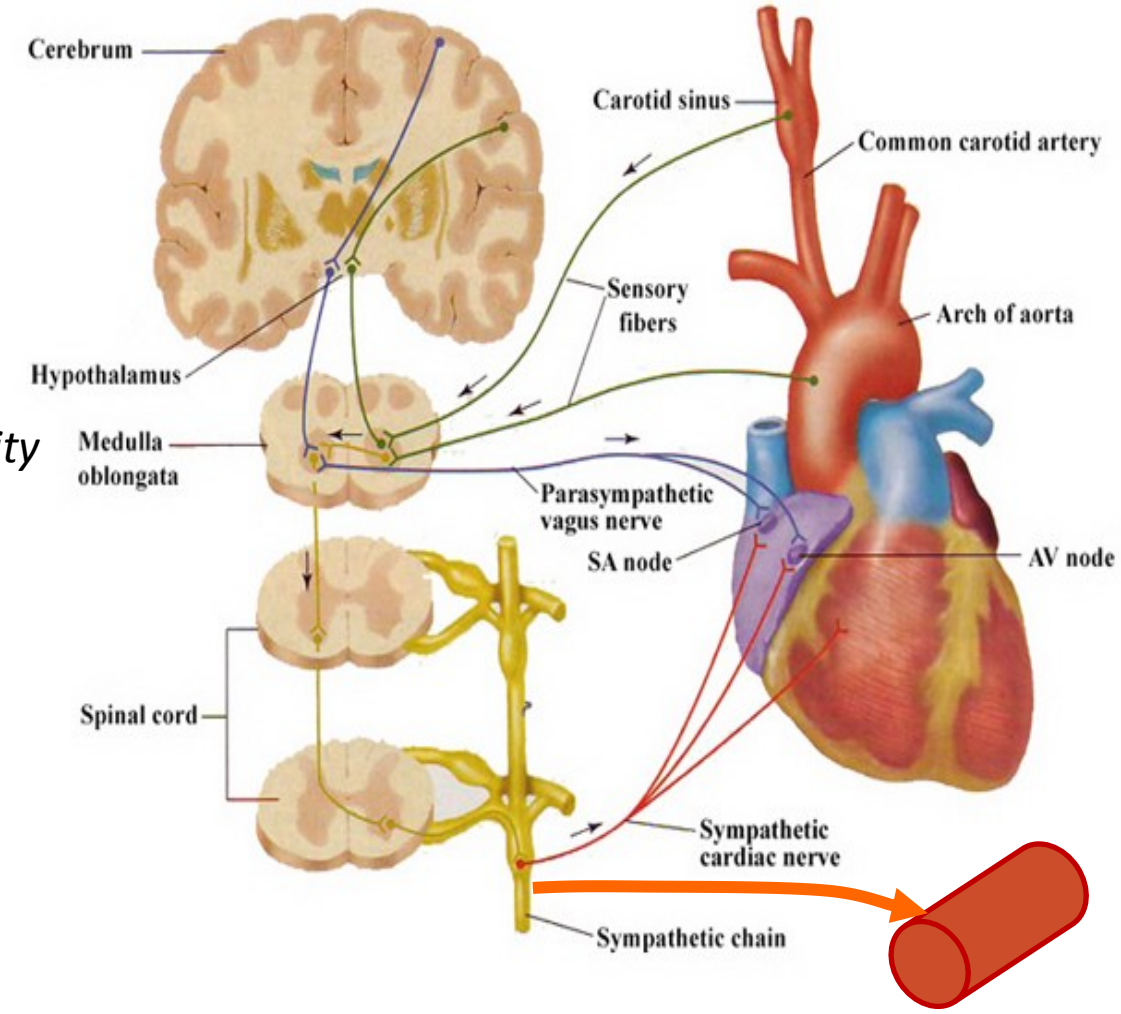
  ↑BP →↓HR and vice versa

- **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 (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

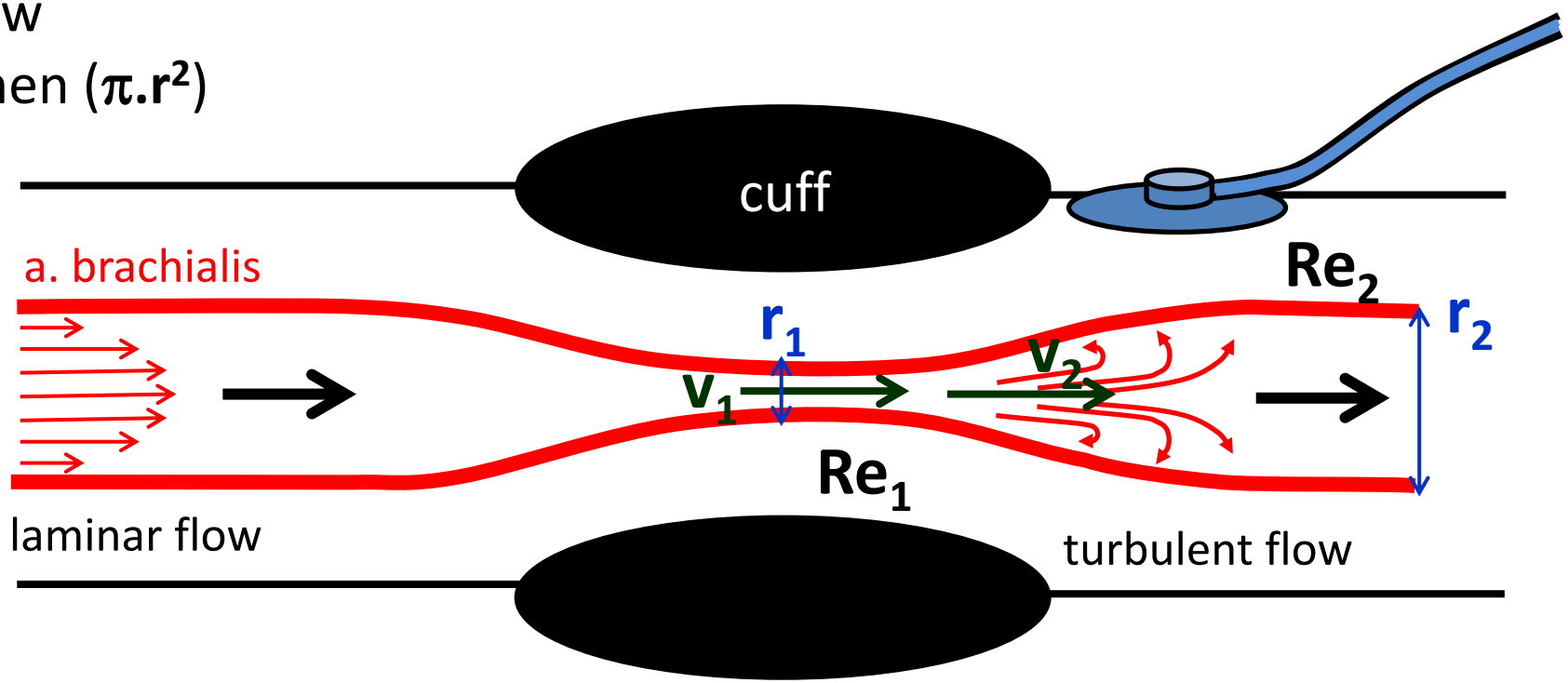
Reynolds number Re: predicts the transition from laminar to turbulent of flo

v: velocity of blood flow

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

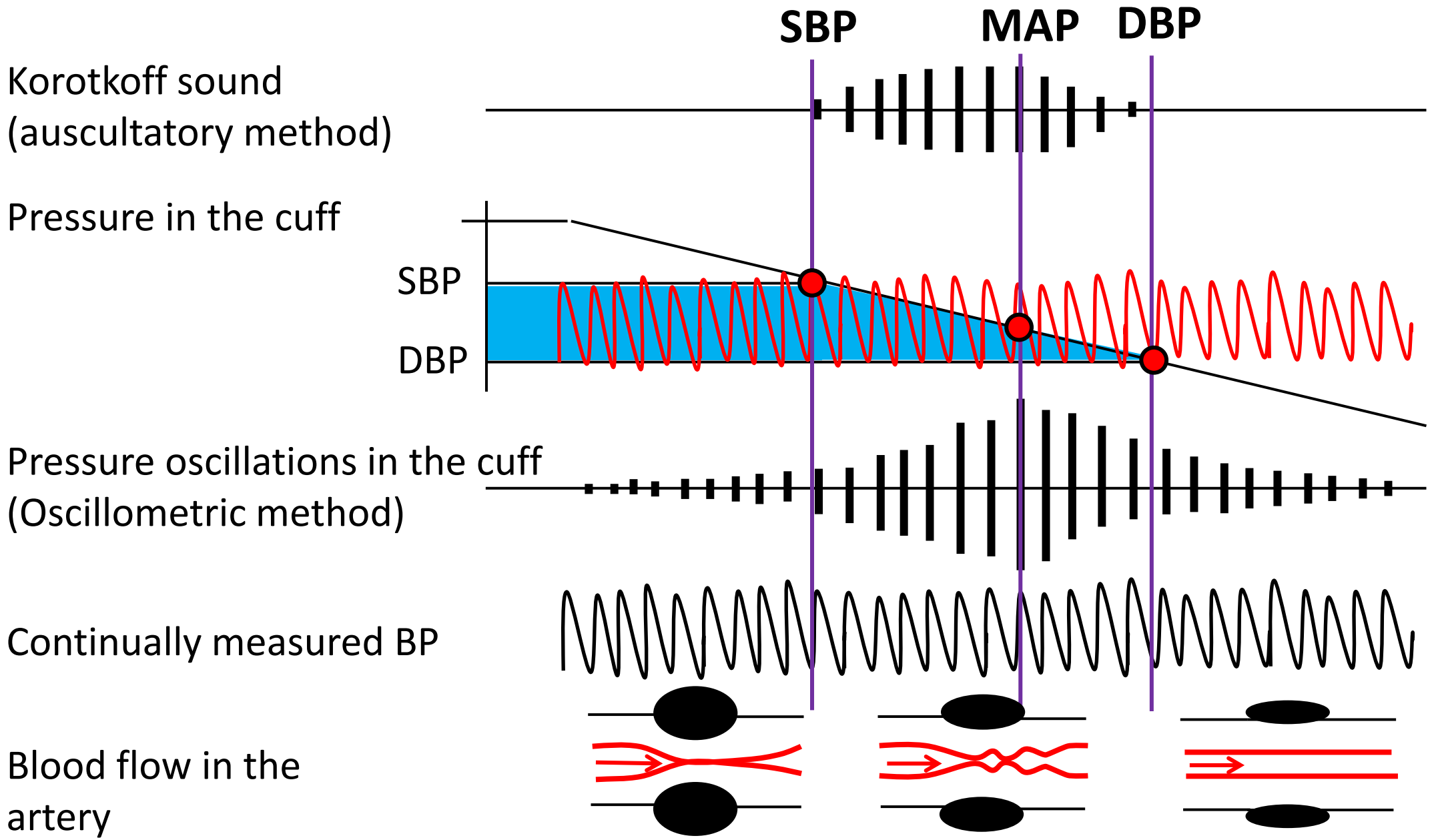
ρ: density of blod

η: viskosit of blood
(higher in anemy)



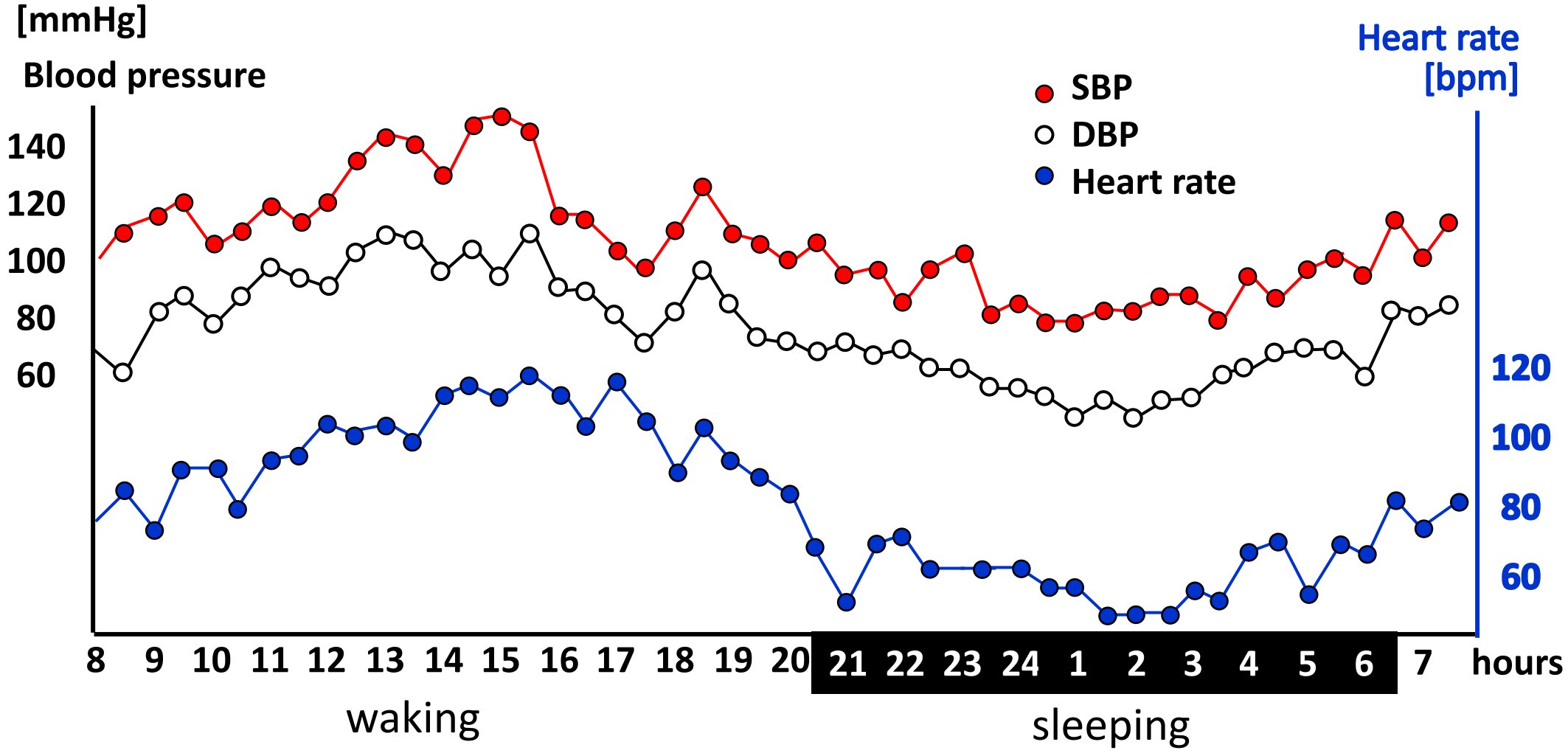
closely behind narrowing of the artery: $S_1 < S_2$ a $v_1 \approx v_2$ → $Re_1 < Re_2$ → turbulent flow

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 doesnt require electricity	• subjective, experience is necesary • SBP/DBP from differen IBI	STK a DTK
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 puls wave) • SBP/DBP from different IBI • false values during arrhytmia	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 mesured 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]	posible complications
normal	optimal	<120	<80	
	normal	120 – 129	80 – 84	
	high normal	130 – 139	85 – 90	
hyper-tension	1. stage	140 – 159	90 – 99	without organ changes
	2. stage	160 – 179	100 – 109	hypertrophy of L ventricle, proteinuria, angiopathy, ...
	3. 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 $\rightarrow$ $\uparrow$STK
  - 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)