

**Regulation**

**in cardiovascular system**

# Types of regulation - general view

2 basic types:

- ✓ Nervous regulation
- ✓ Humoral regulation
  - ✓ Feedback control - negative
  - ✓ - positive

autoregulation – local regulation – system regulation

# REGULATION IN CARDIOVASCULAR SYSTEM

Main function:

- keep relatively constant arterial blood pressure
- Keep perfusion of tissues

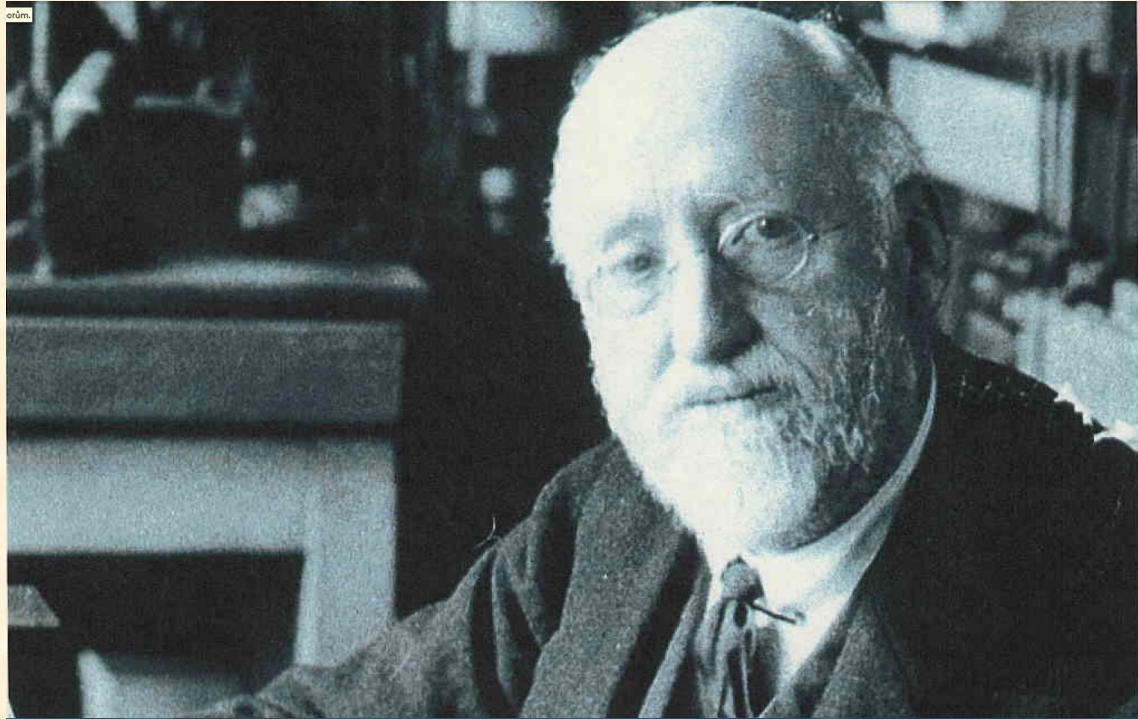
# Regulation of vessels tone

- Tone of the vessels = basic tension of the smooth muscle inside of the wall  
(vasoconstriction x vasodilatation)
- Regulation - local autoregulation  
- system regulation

# Autoregulation

Autoregulation – the capacity of tissues to regulate their own blood flow

**Myogenic theory** – Bayliss phenomenon (as the pressure rises, the blood vessels are distended and the vascular smooth muscle fibres that surround the vessels contract; the wall tension is proportional to the distending pressure times the radius of the vessels – law of Laplace)



# Autoregulation

- **Metabolic theory** – vasodilator substances tend to accumulate in active tissue, and these metabolites also contribute to autoregulation
  - ending products of energetic metabolism –  $\text{CO}_2$ , lactate acid,  $\text{K}^+$
  - effect of hypoxia (circulation: vasodilatation x pulmonary circulation: vasoconstriction)
  - Adenosin – coronary circulation: vasodilatation



# Autoregulation

- **by substances which releasing from:**
  - endothelium
  - tissues



## **Substances secreted by the ENDOTHELIUM**

### ***Vasodilatation:***

Nitric oxide (NO) from endothelial cells  
(originally called: EDRF)

Prostacyclin is produced by endothelial cells

### ***Vazoconstriction:***

Endothelins (polypeptids – 21peptides)

three isopeptides: ET 1, ET 2 , ET 3

## **Substances secreted by the tissues:**

### **Histamine – primarily tissue hormones.**

General affect: vasodilatation - decrease periphery resistance, blood pressure

### **KININS: 2 related vasodilated peptides**

#### **Bradykinin + lysylbradykinin (kallidin).**

Sweat glands, salivary glands

10x stronger than histamine

Relaxation of smooth muscle, decrease blood pressure

# Systemic regulation

## By hormones

Catecholamines – epinephrine, norepinephrine  
- effect as activation of sympathetic system

RAAS - stress situation

ADH - general vasoconstriction

Natriuretic hormones - vasodilatation

# Neural regulatory mechanism

## Autonomic nervous system

### *Sympathetic: vasoconstriction*

All blood vessels except capillaries and venules contain smooth muscle and receive motor nerve fibers from sympathetic division of ANS (noradrenergic fibers)

- Regulation of tissue blood flow
- Regulation of blood pressure

### *Parasympathetic part: vasodilatation*

Only sacral parasympathetic cholinergic fibres (Ach) innervated arteriols from external sex organs

# INTEGRATION of regulation in cardiovascular system

## *The regulation of the heart:*

– Rami cardiaci n. vagi

**Cardiac decelerator center** - medula oblongata  
(ncl.dorsalis, ncl. ambiguus) – parasympathetic  
fibres of nervus vagus

: vagal tone (tonic vagal discharge)

Negative chronotropic effect (on heart rate)

Negative inotropic effect (on contractility)

Negative dromotropic effect (on conductive tissue)

# INTEGRATION of regulation in cardiovascular system

## *The regulation of the heart:*

- nn. cardiaci

**Cardiac accelerator center** – spinal cord,  
sympathetic ganglia – sympathetic NS

Positive chronotropic effect (on heart rate)

Positive inotropic effect (on contractility)

Positive dromotropic effect (on conductive tissue)

# INTEGRATION of regulation in cardiovascular system

***Vasomotor centre*** (regulation for function of vessels)

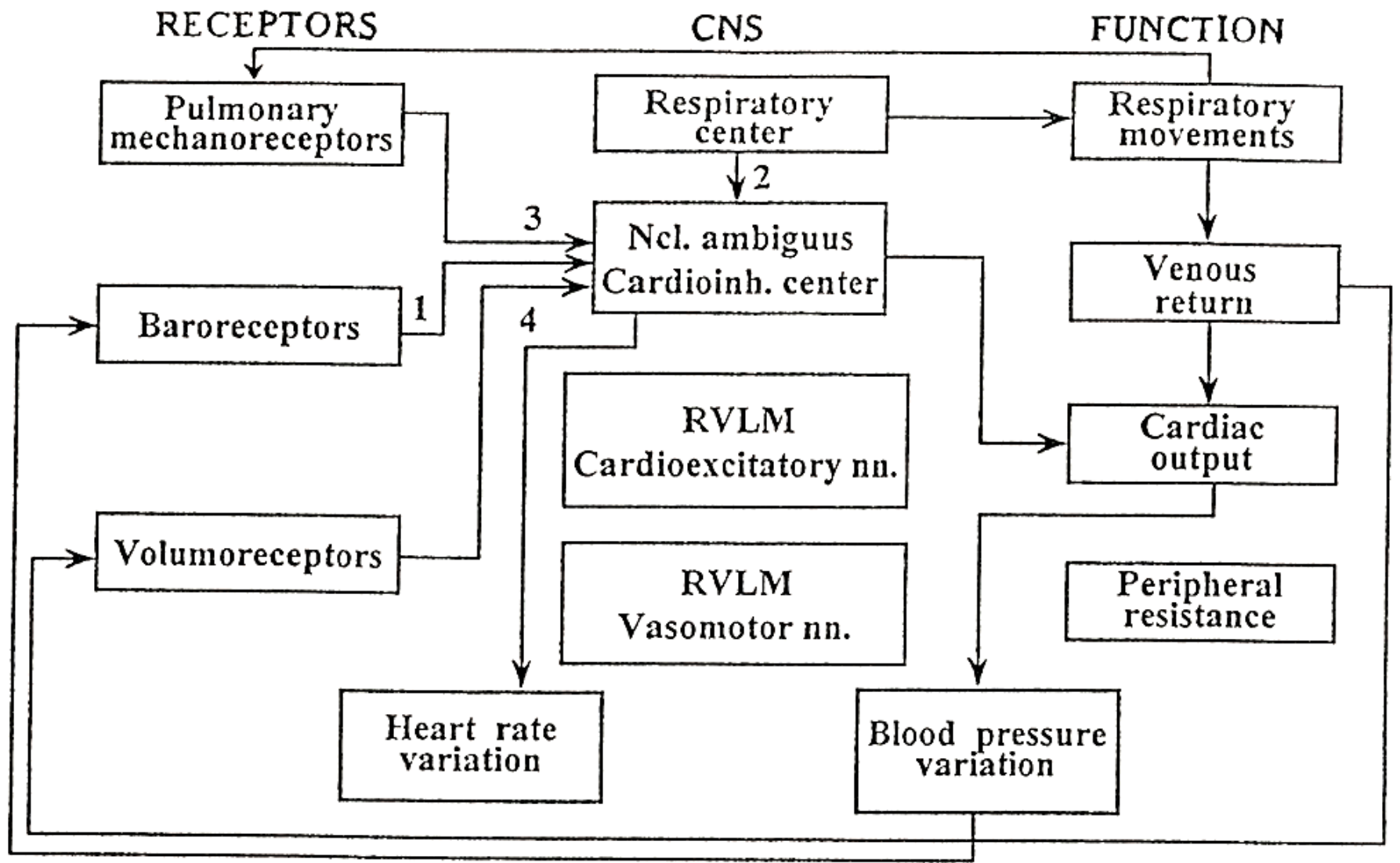
Medula oblongata

- ✓ *presoric area* (rostral and lateral part – vasoconstriction – increase blood pressure)
- ✓ *depresoric area* (medio-caudalis part – vasodilatation, decrease of blood pressure)



# INTEGRATION of regulation in cardiovascular system

- Influence by central nervous system
  - cerebral cortex
  - limbic cortex
  - hypothalamus



# Regulation of blood pressure

Short - term regulation

- baroreflex

Middle - term regulation

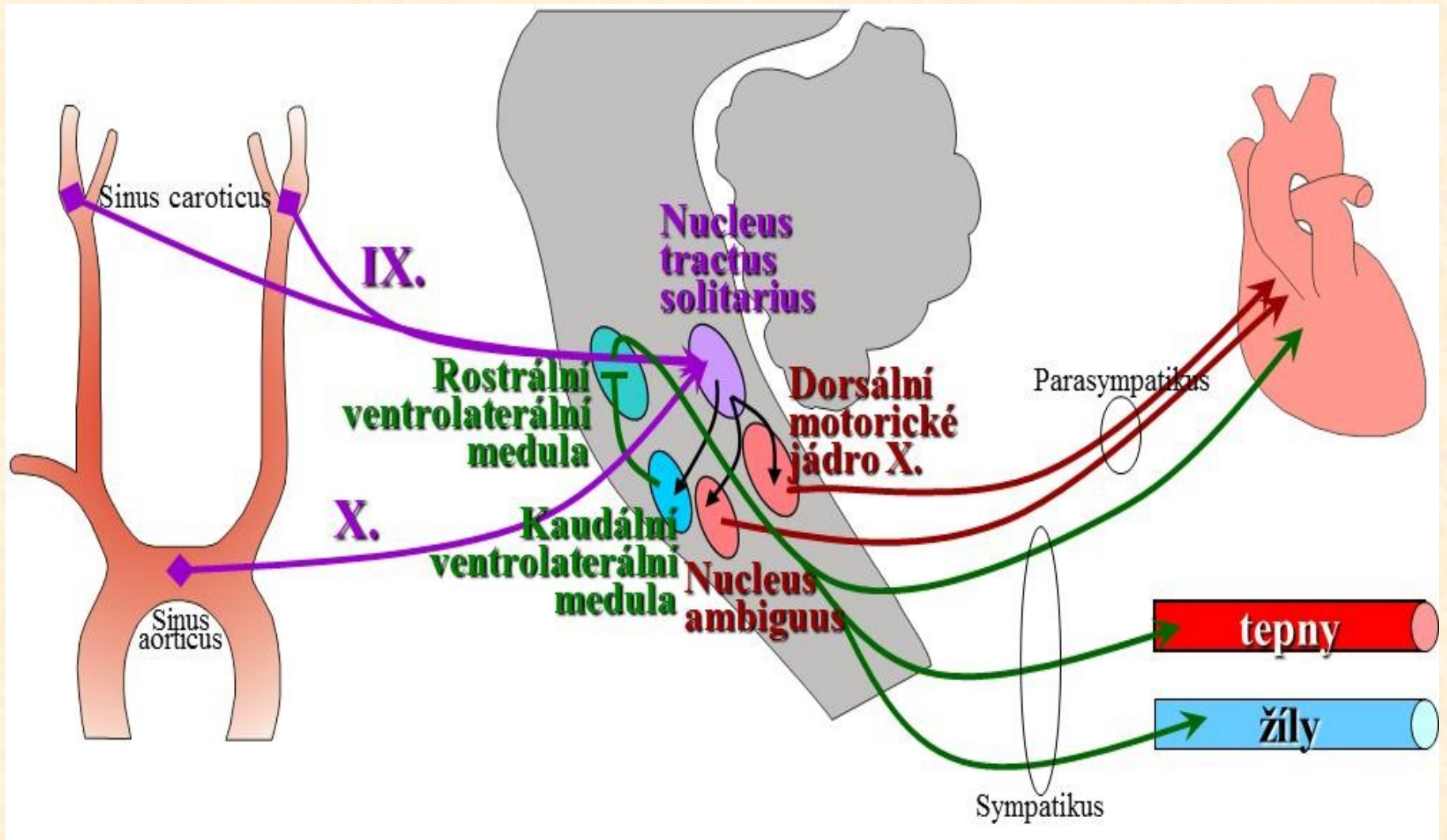
- humorals regulation
- sympathetic - catecholamines
- RAAS
- ADH

Long – term regulation

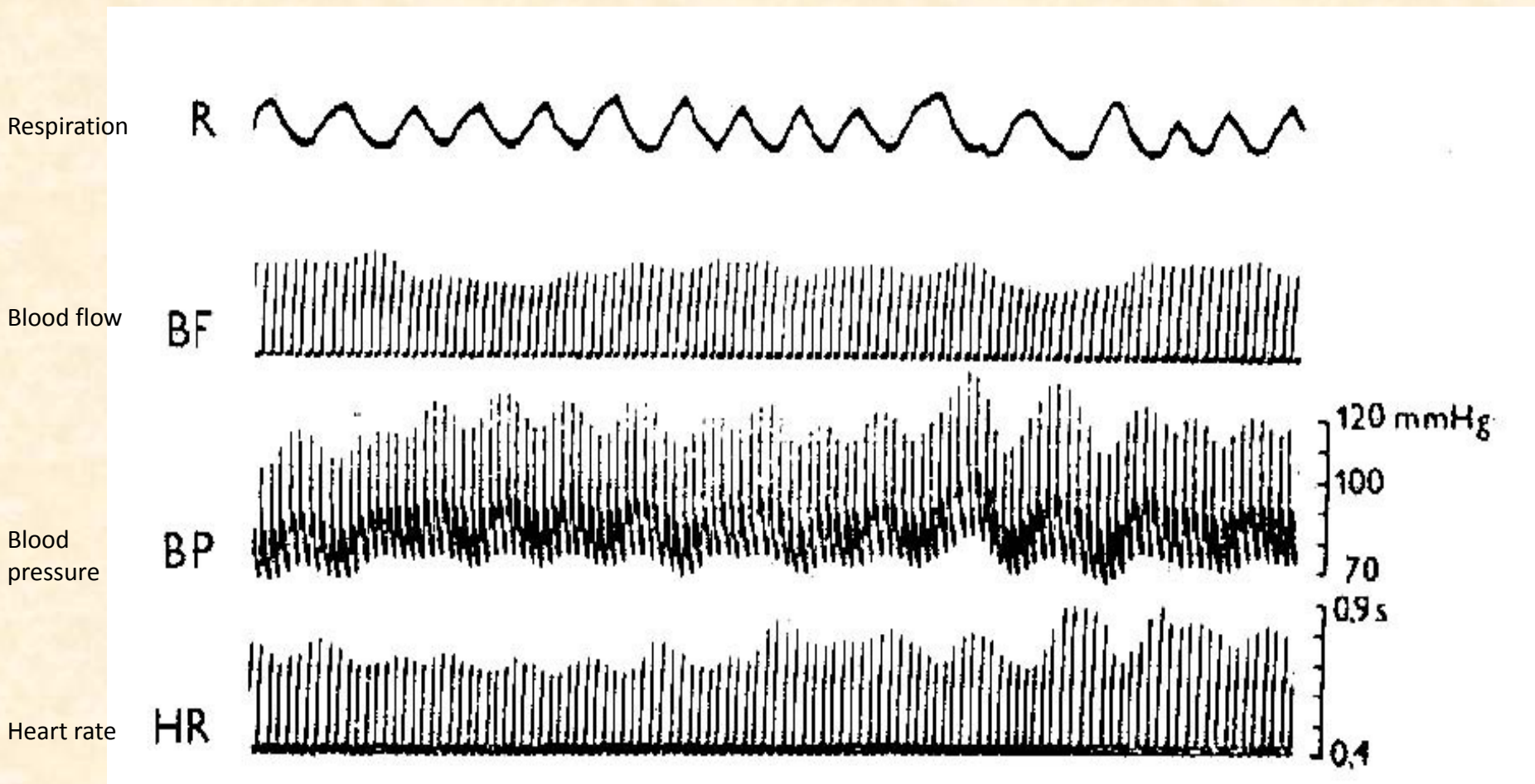
- kidney regulation

# Short term regulation

## BAROREFLEX



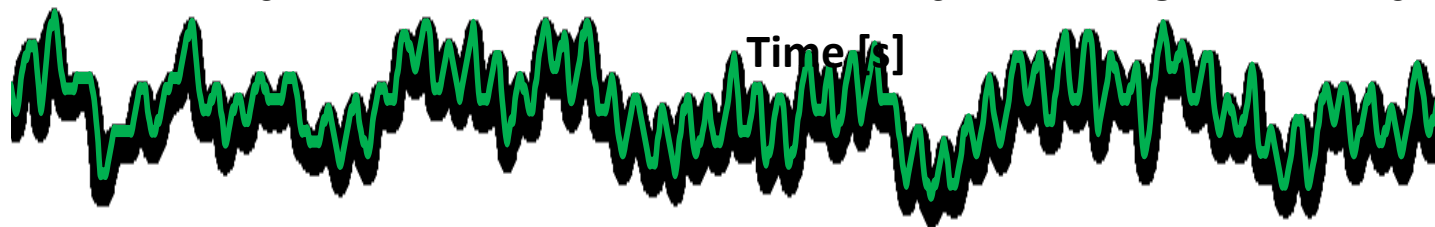
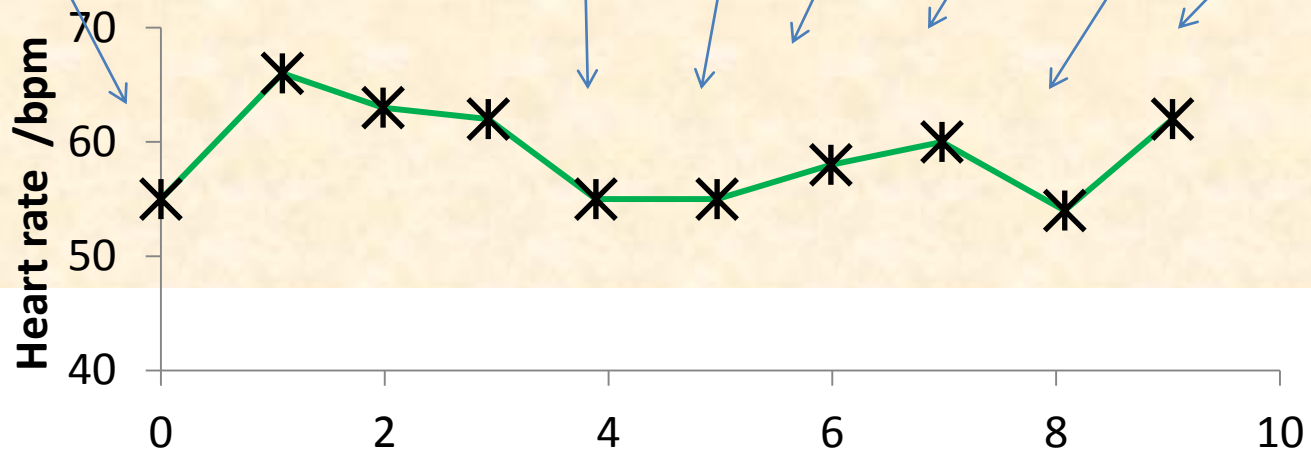
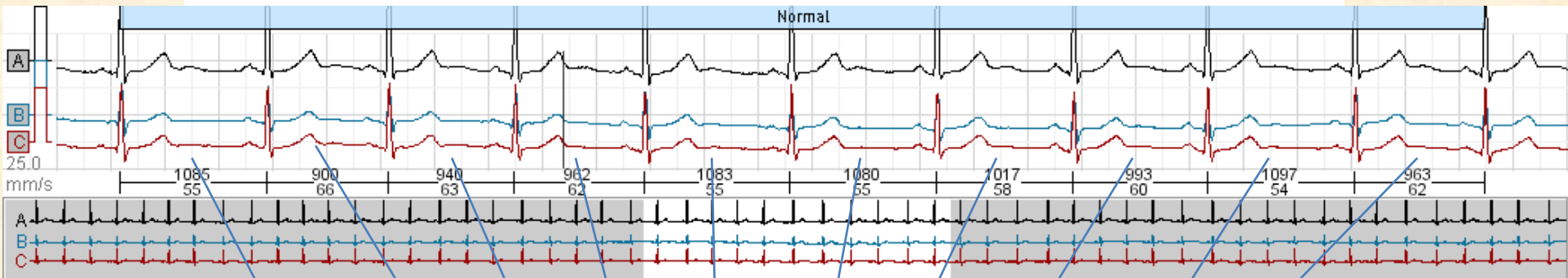
# original record of waves in circulatory parameters (photoplethysmography by Peñáz)





# Variability of circulatory parameters

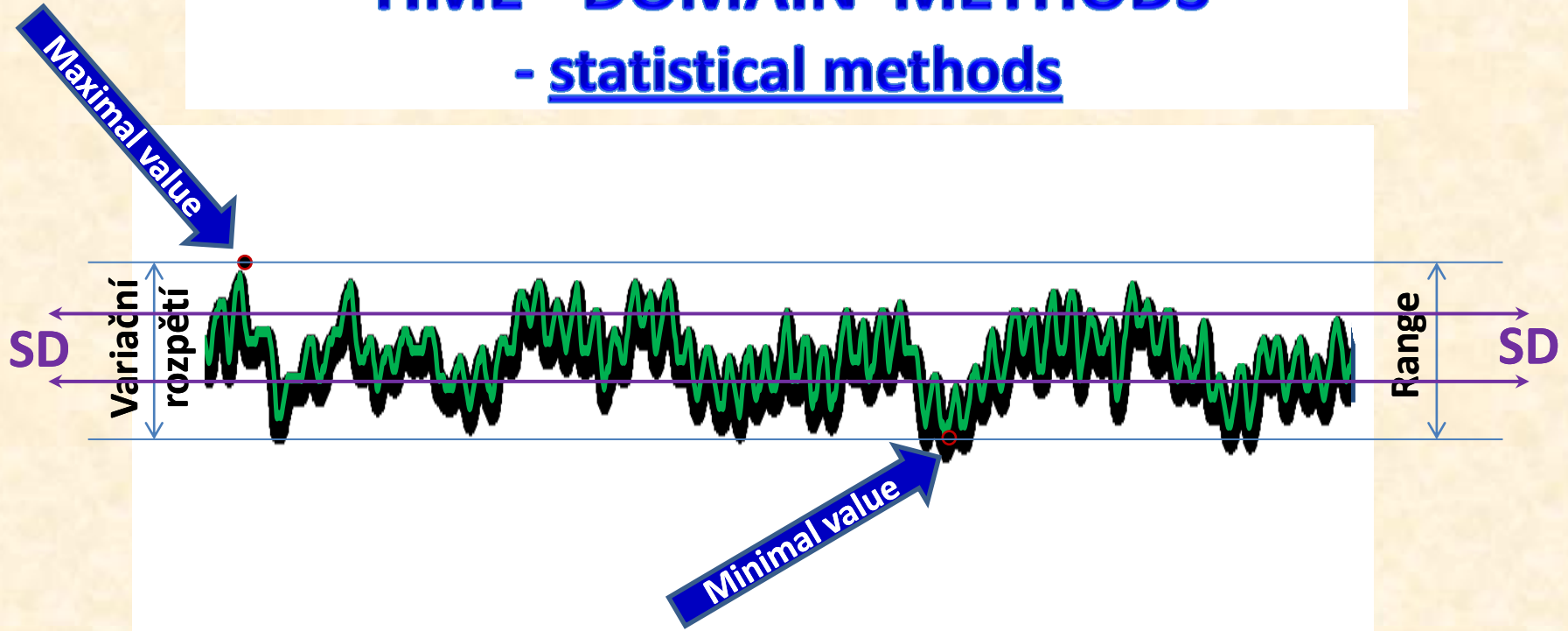
## TIME - DOMAIN METHODS



# Variability of circulatory parameters

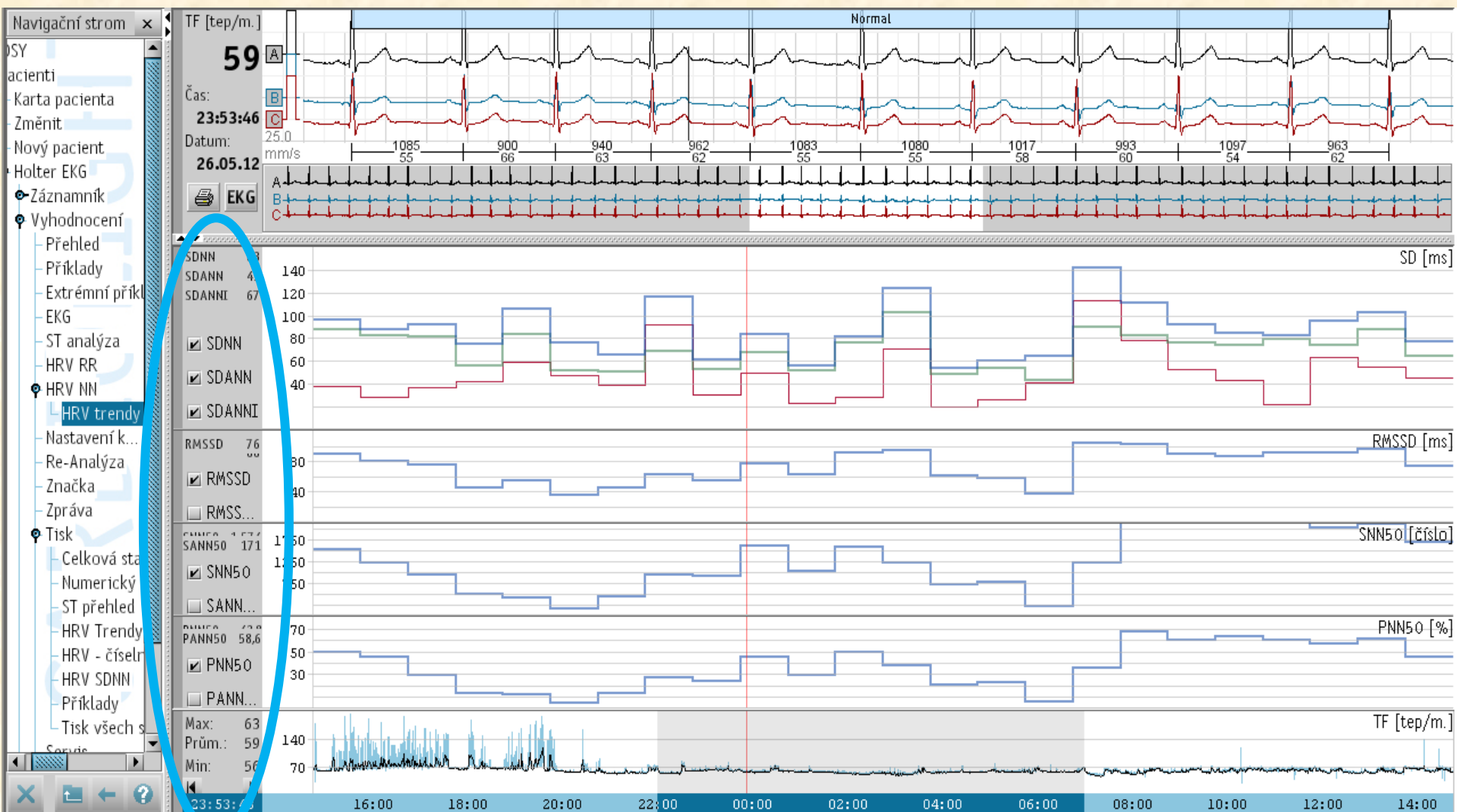
## TIME - DOMAIN METHODS

### - statistical methods





# Example: ECG – Holter monitoring



# Variability of circulatory parameters TIME - DOMAIN METHODS - geometrical methods

840 x

828 y x

760 y x

756 y x

808 y x

856 y

768

780

808

756

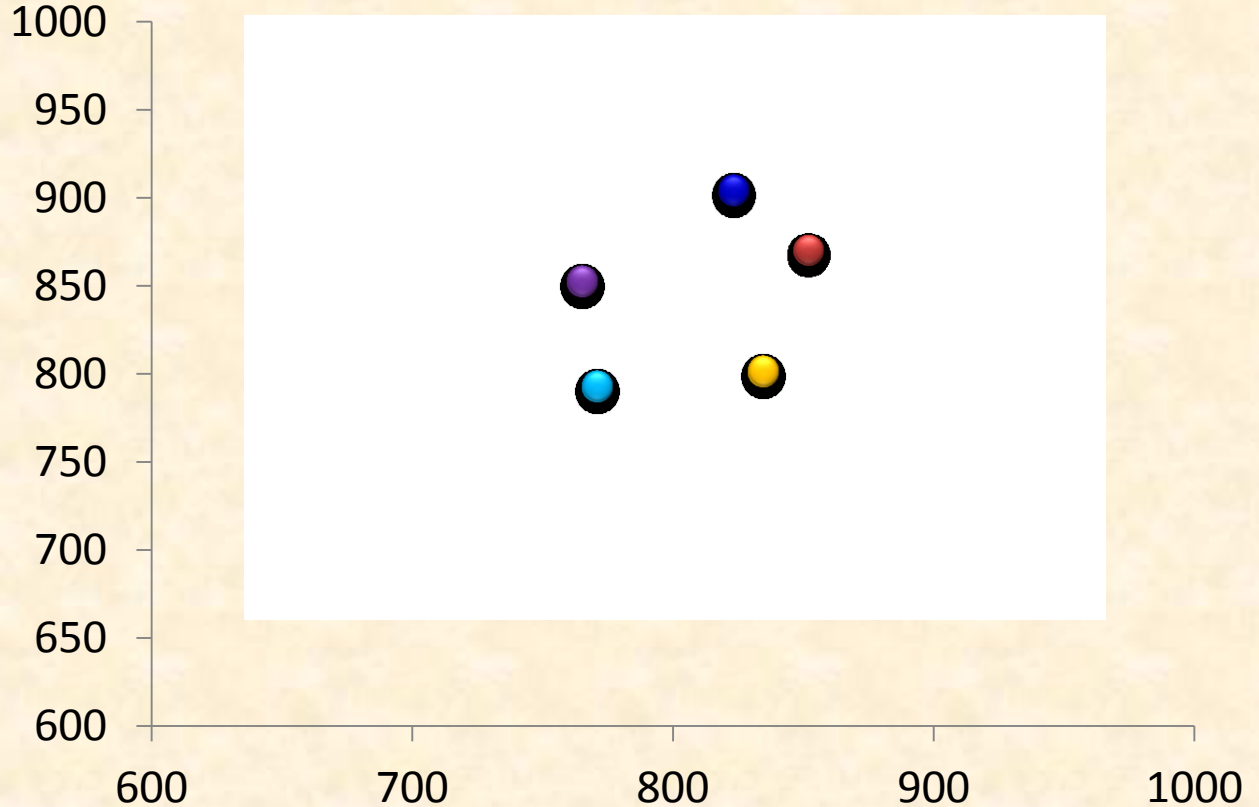
708

728

756

732

708



- **Spectral analysis:**
- Carried out under standard conditions at various maneuvers (supine, standing); evaluated with 300 representative intervals RR / NN /
- Another mathematical processing (Fourier transform) -length RR intervals are converted to cycles in Hz
- The spectrum is divided into several components - low (LF: the sympathetic modulation) and high frequency (HF: vagal modulation)
- **People with reduced heart rate variability have a 5 times higher risk of death**

# Variability of circulatory parameters

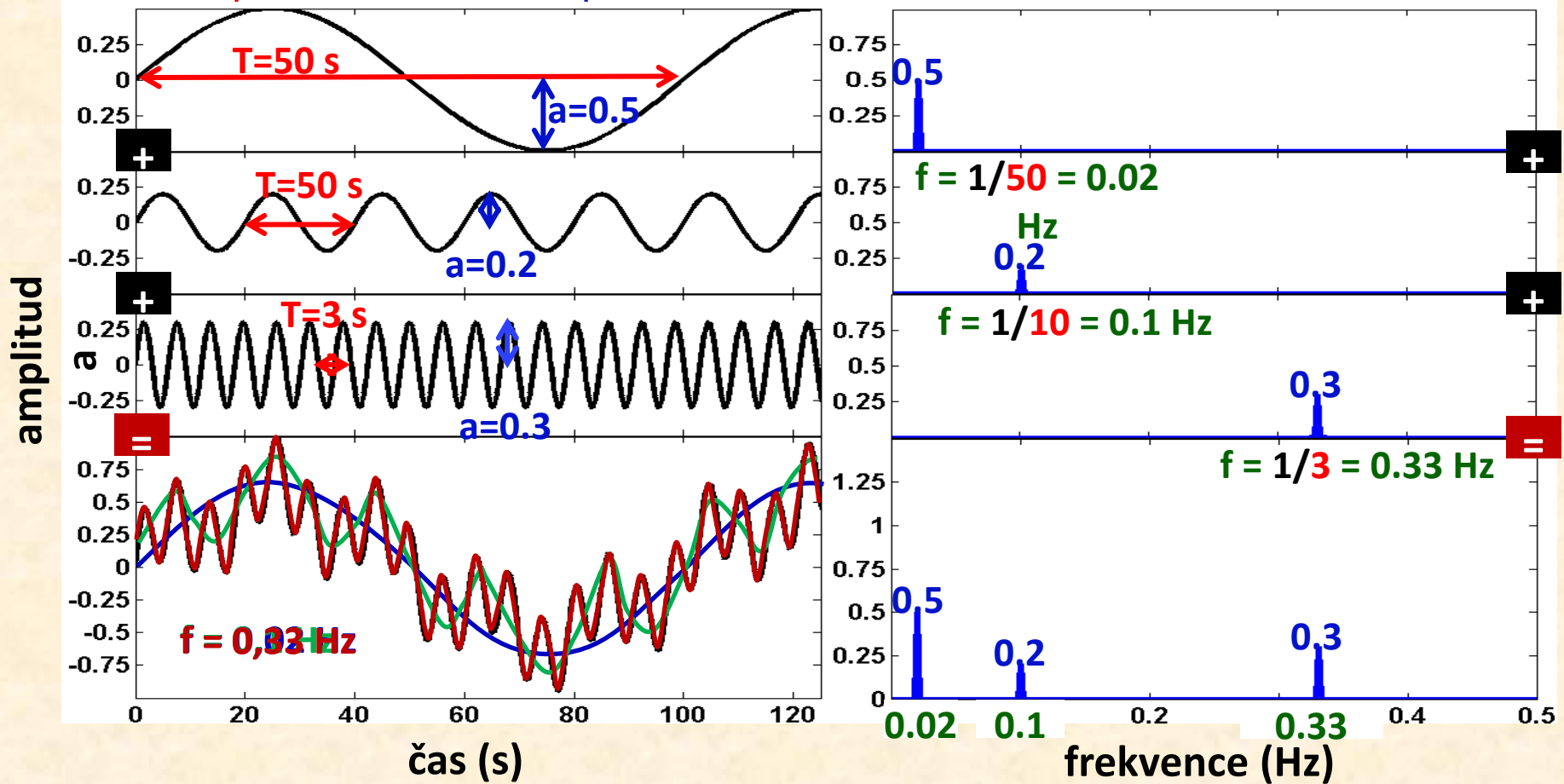
## FREQUENCY - DOMAIN METHODS

### - spectral analysis

perioda  $T$

amplituda  $a$

frekvence  $f = 1/T$



# VARIABILITY OF CIRCULATORY PARAMETERS

