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 constantaneous 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 – CO_2, lactate acid, 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 resistence, blood pressure

KININS: 2 related vasodilated peptides

Bradykinin + lysylbradykinin (kallidin).

Sweat glands, salivary glands

10x strongers 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) inervated 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)

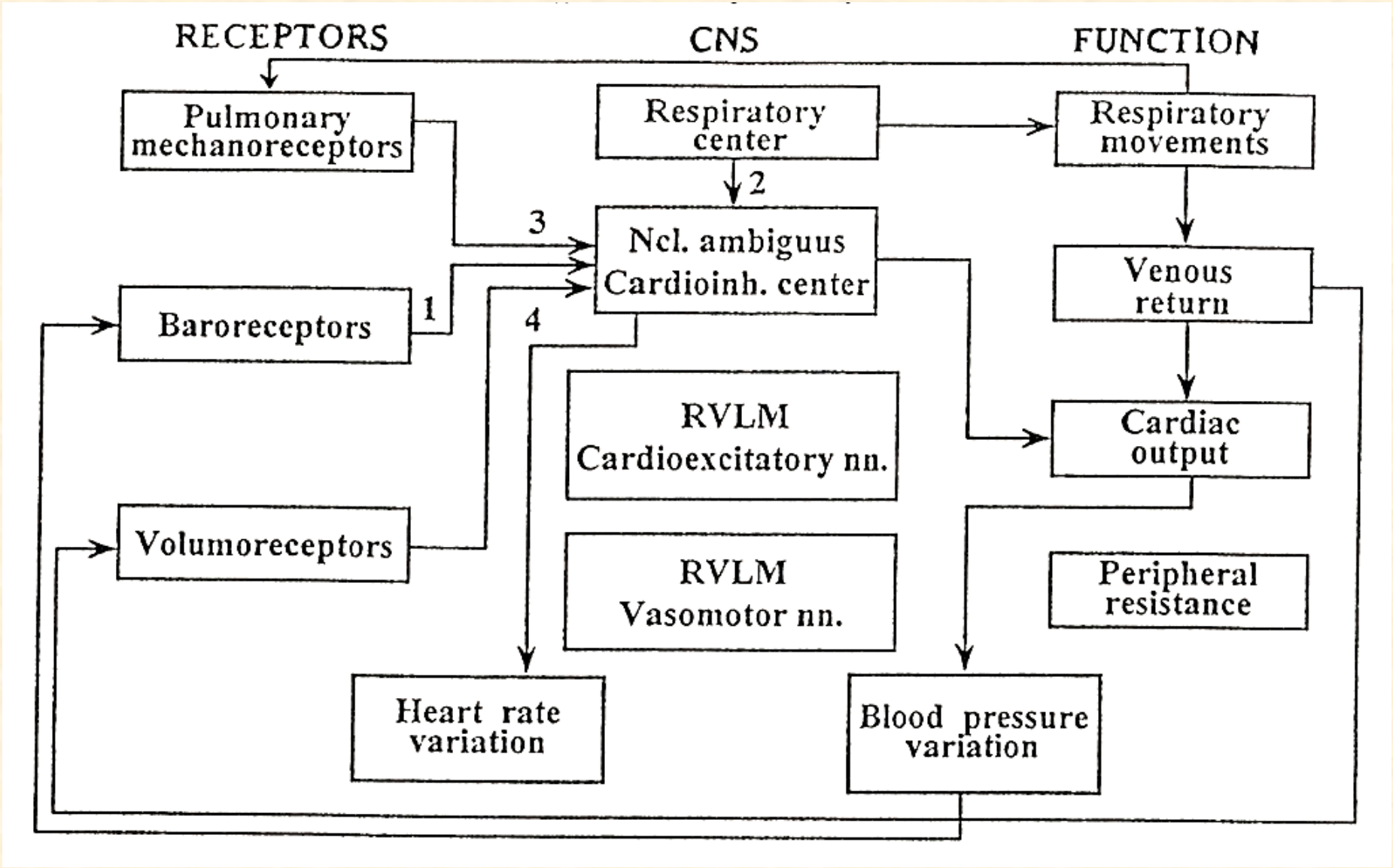
Medula oblongata

- ✓ *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


RECEPTORS
CNS
FUNCTION
Pulmonary mechanoreceptors
Respiratory center
Respiratory movements
2
3
Ncl. ambiguus
Cardioinh. center
Venous return
Baroreceptors
1
4
RVLM
Cardioexcitatory nn.
Cardiac output
Volumoreceptors
RVLM
Vasomotor nn.
Peripheral resistance
Heart rate variation
Blood pressure variation

Regulation of blood pressure

Short - term regulation

- baroreflex

Middle - term regulation

- humorals regulation

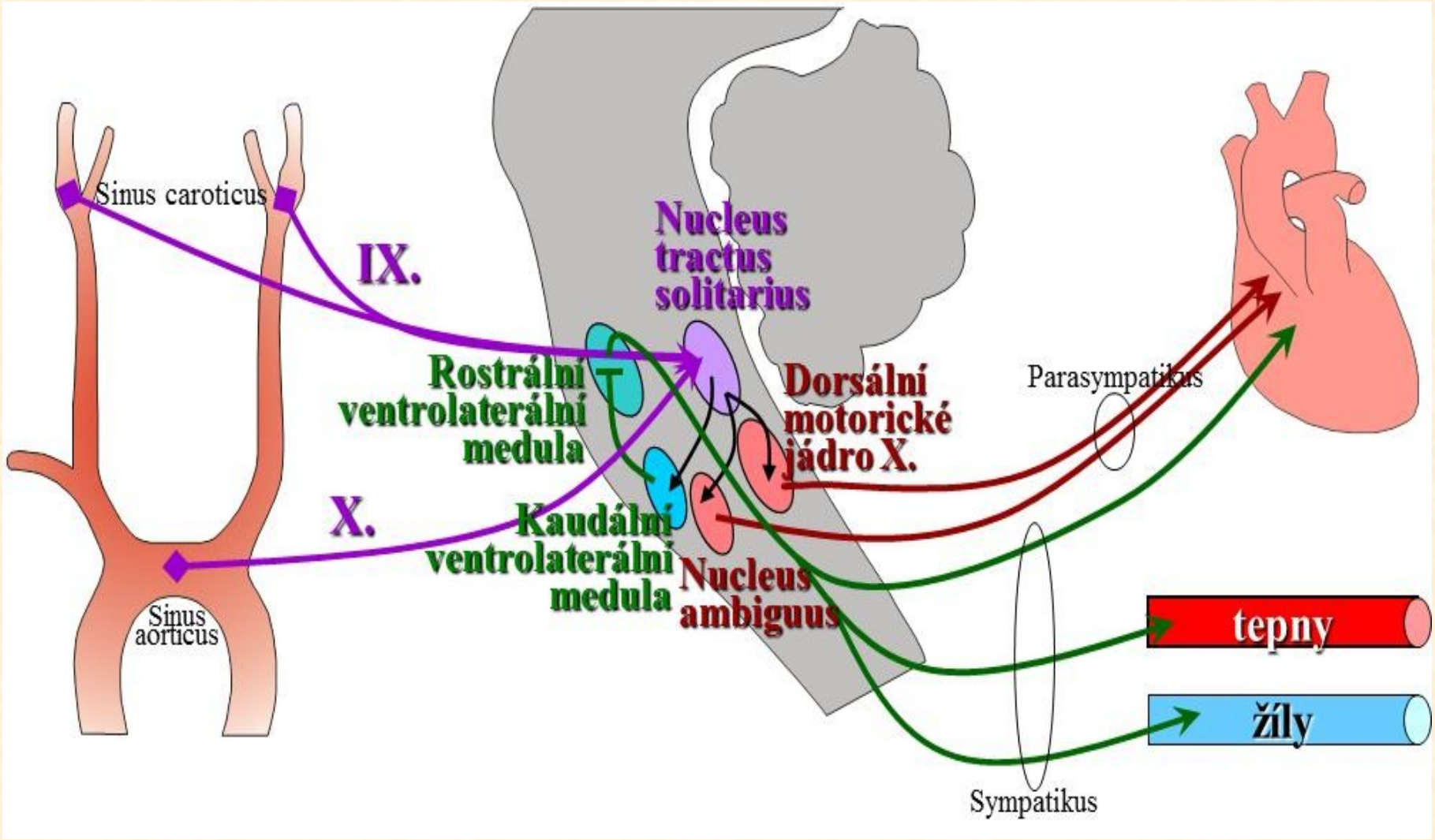
- sympathetic - catecholamines
- RAAS
- ADH

Long – term regulation

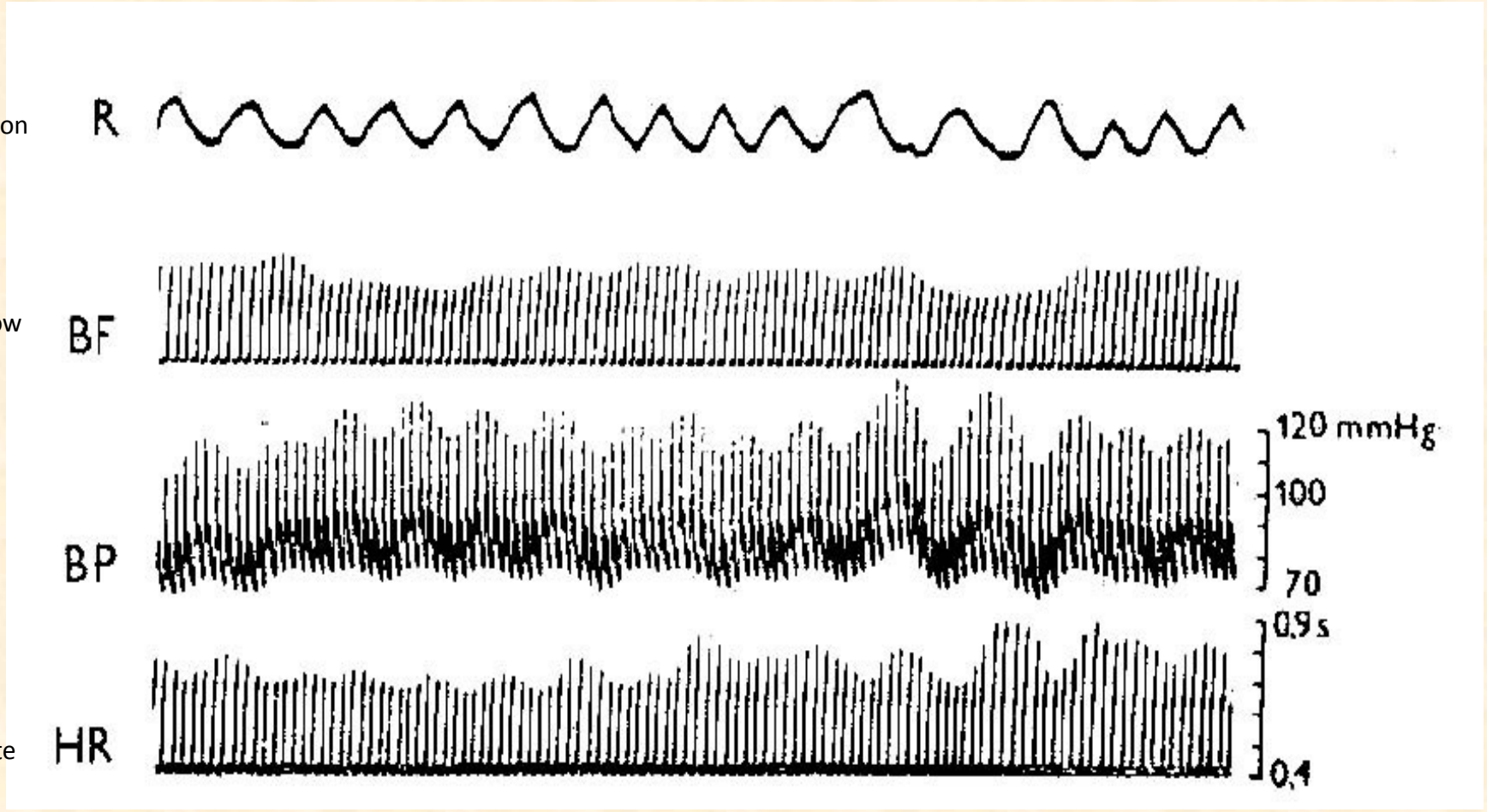
- kidney regulation

Short term regulation

BAROREFLEX

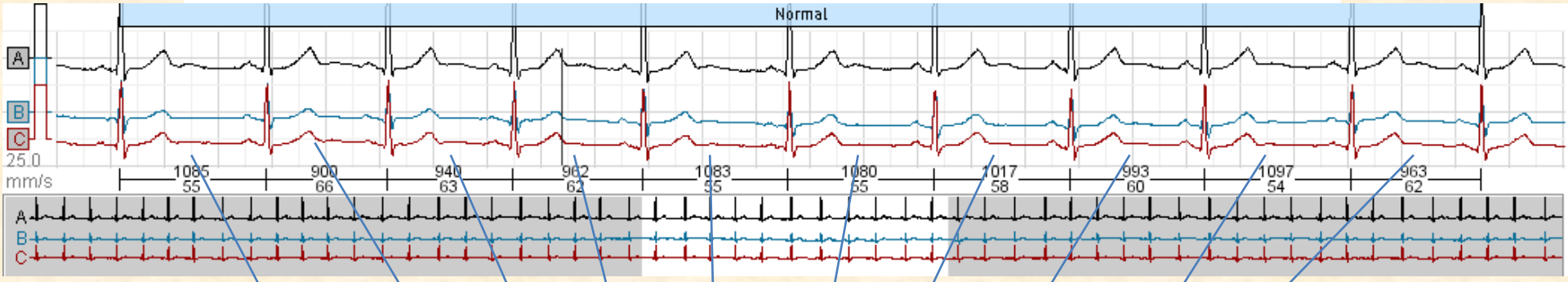


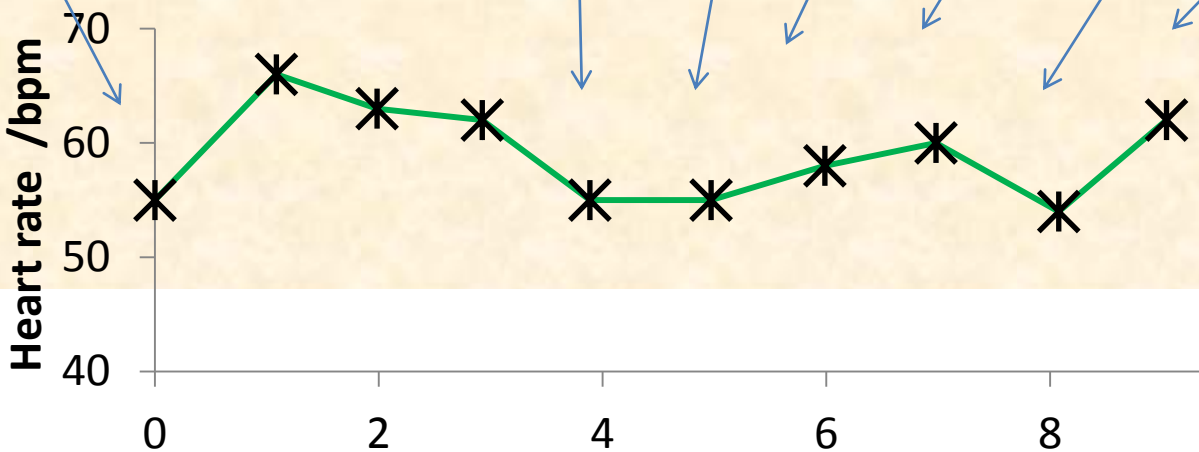
original record of waves in circulatory parameters
(photoplethysmography by Peňáz)

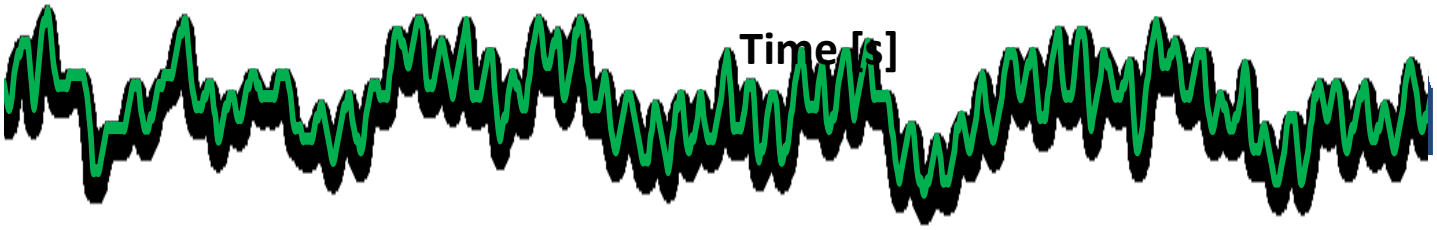


Variability of circulatory parameters

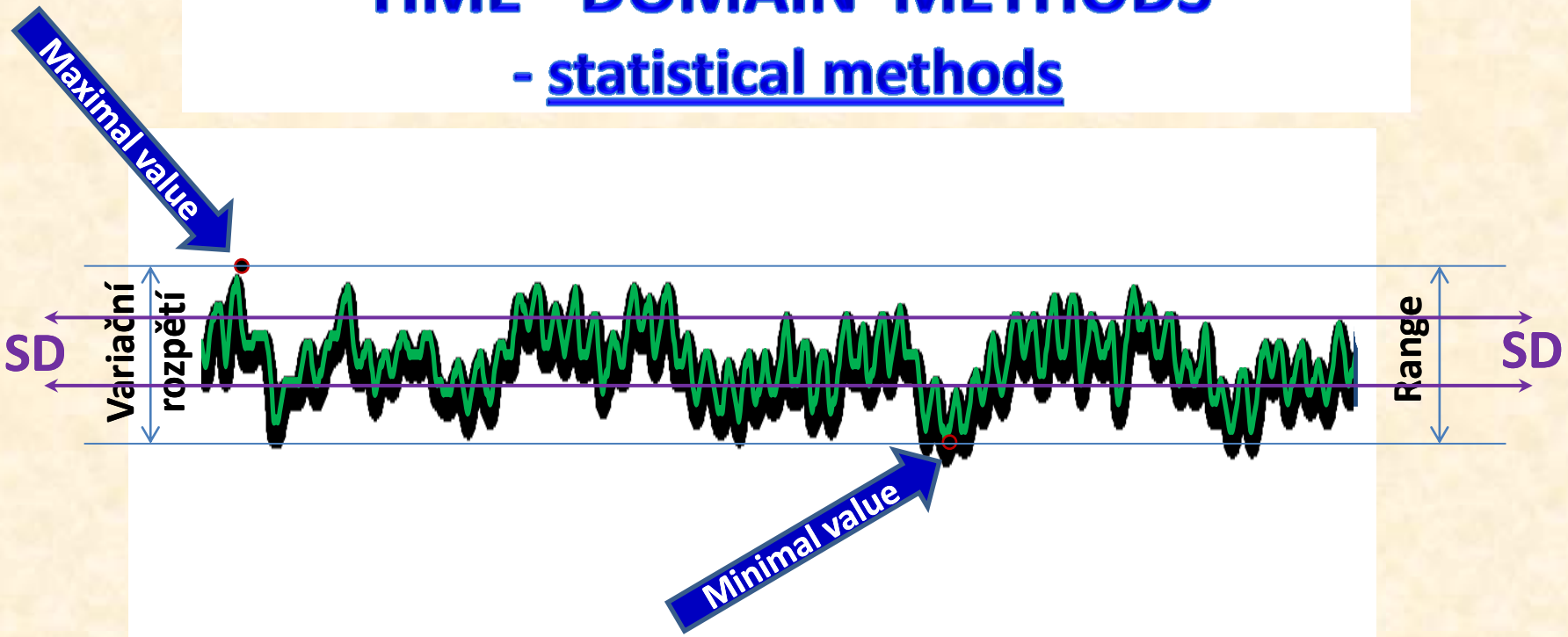
TIME - DOMAIN METHODS



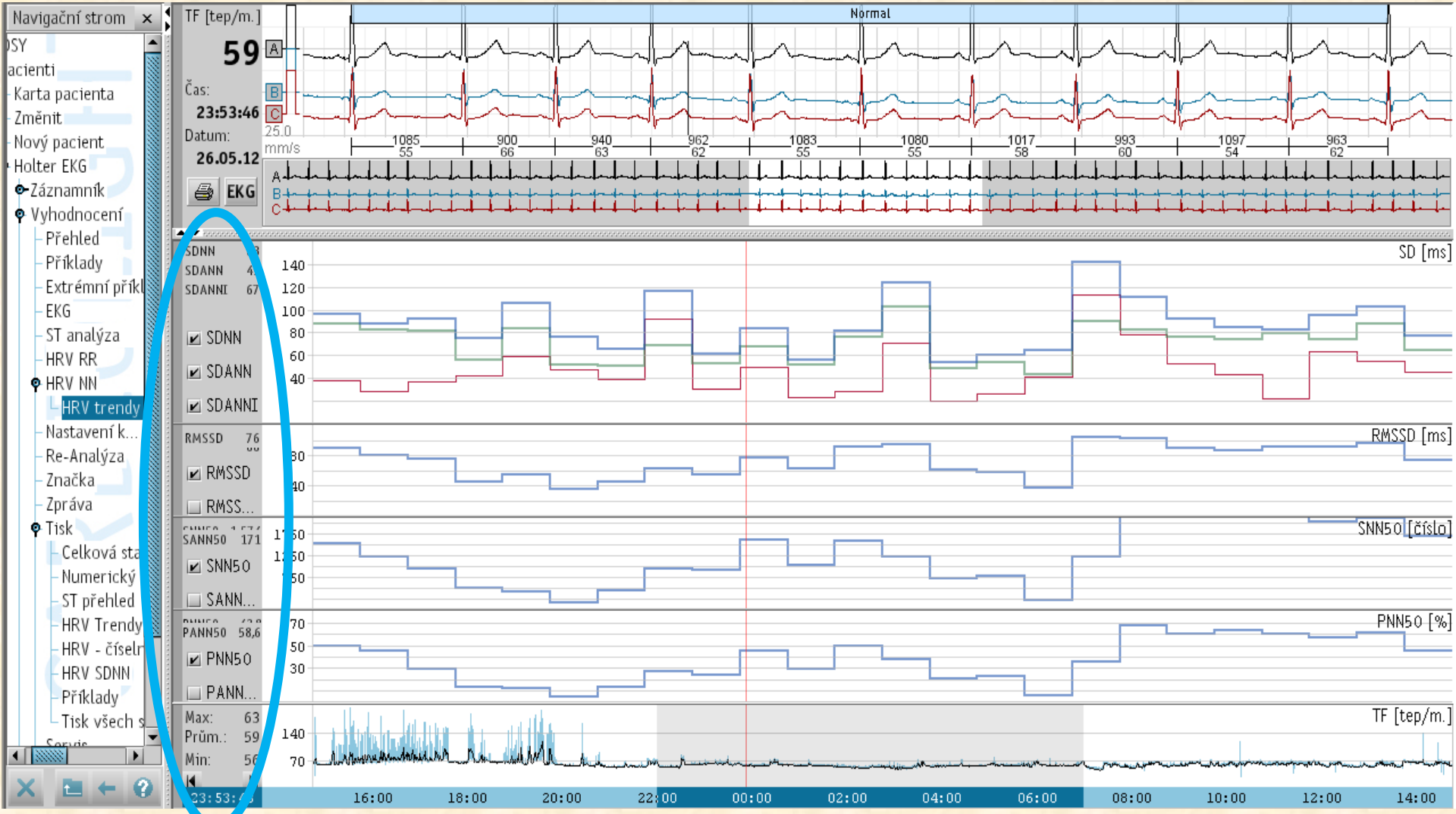




Variability of circulatory parameters
TIME - DOMAIN METHODS
- statistical methods

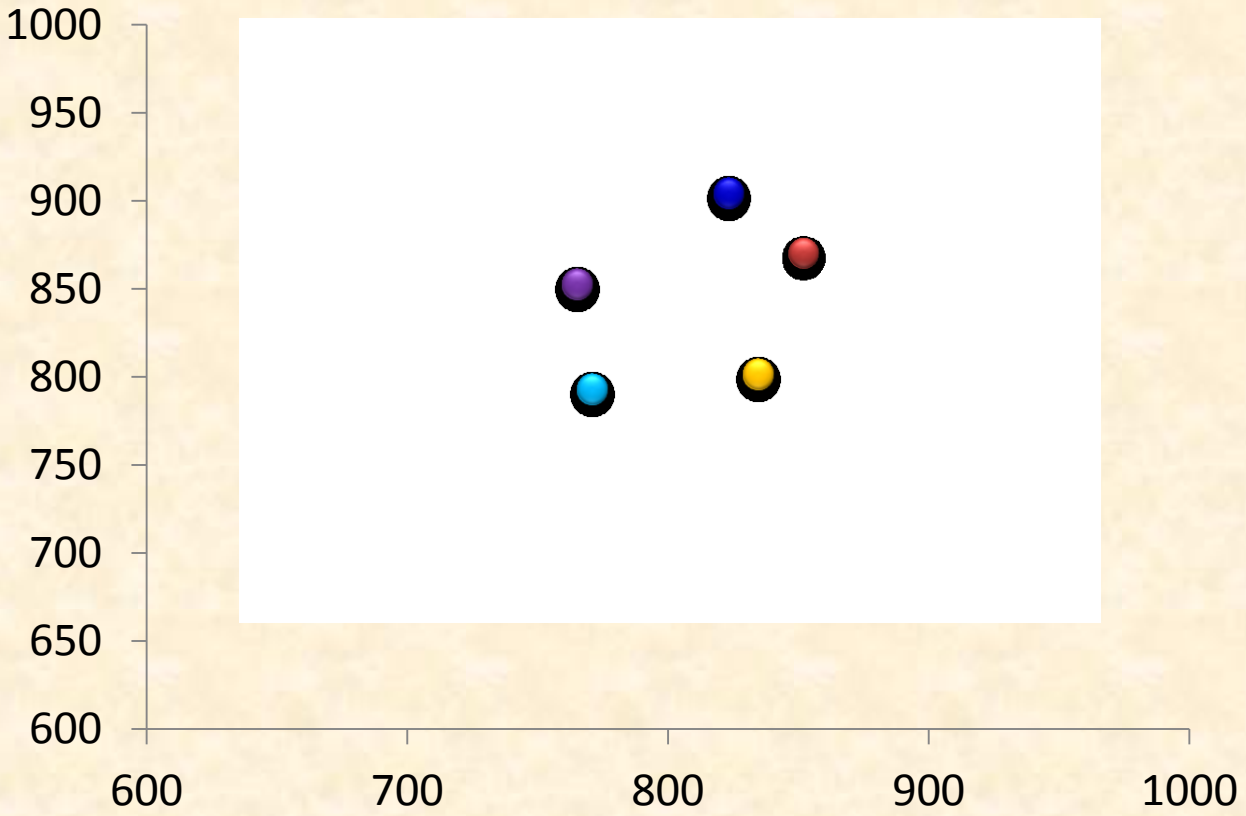


Example: ECG – Holter monitoring



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

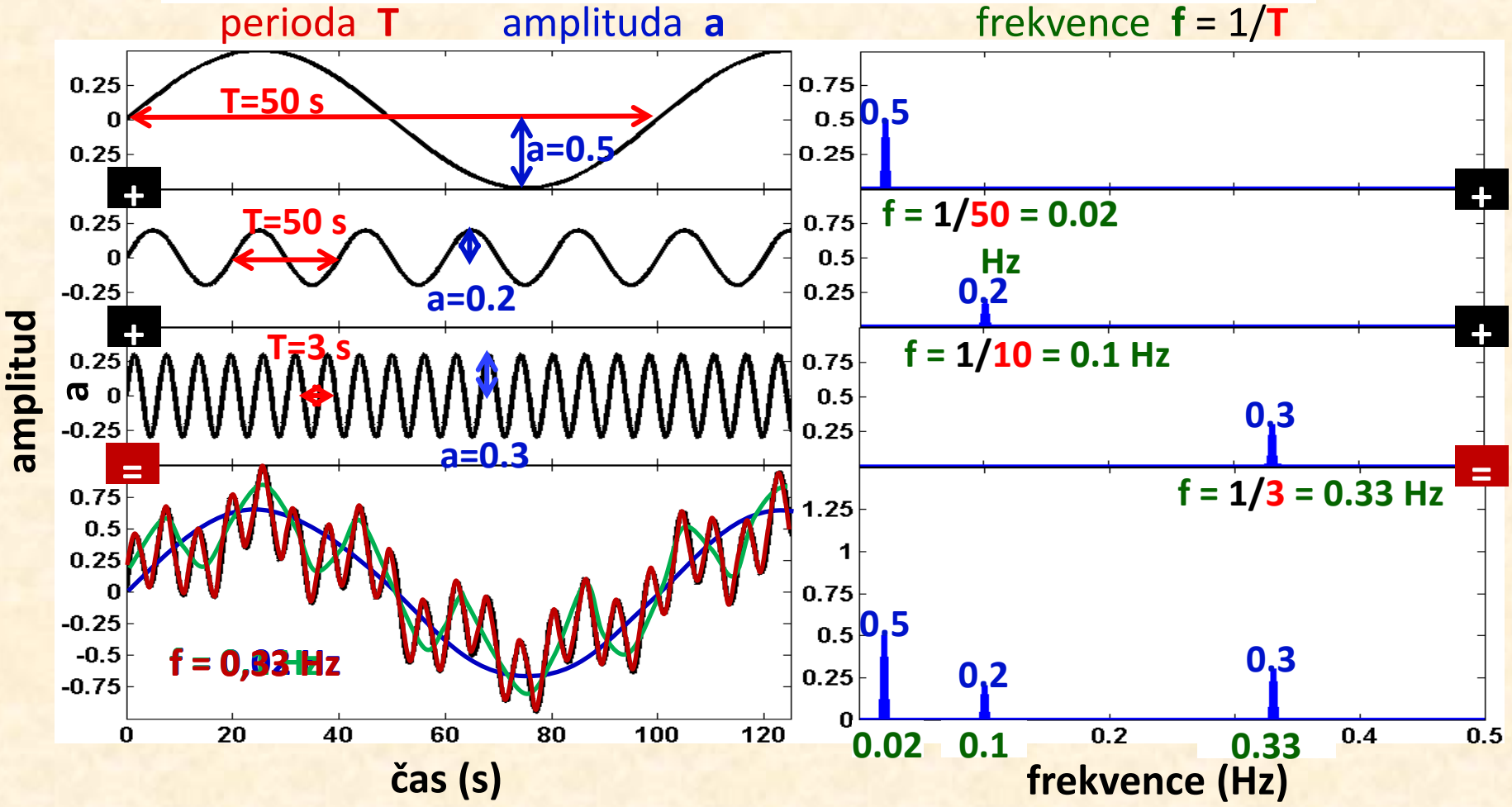


- **Spectral analysis:**
- Carried out under standard conditions at various maneuvers (supine, standing); evaluated with 300 representative intervals RR / NN /
- Another mathematical processing (Fourier transform) -length RR intervals are converted to cycles in Hz
- The spectrum is divided into several 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



VARIABILITY OF CIRCULATORY PARAMETERS