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

Thromboxane A2 promotes platelet aggregation
(important prostacyclin – thromboxan balance)

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

Serotonin - occurrence: chromaffin cells GIT, CNS, platelets

Binding: serotonin + 5 HT receptors - after binding to the receptor, the smooth muscle of blood vessels, bronchi and intestine will contract

The effect on the circulation depends on the specific properties of the vascular circulation in individual organs:

- vasodilation of blood vessels - skeletal muscles, skin
- vasoconstriction of blood vessels - kidneys, brain, lungs, splanchnic circulation

- Notice: serotonin - as a neurotransmitter - affects sleep and wakefulness processes, behavior, food intake, thermoregulation.

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

- Cardiovascular centers are affected by information from the periphery and other areas of the CNS:
  - from reticular formation in pons, midbrain, diencephalon
  - from the hypothalamus (posterior hypothalamus is related to sympathetic NS)
  - from the cerebral cortex - motor area - regulation of flow through skeletal muscles
  - limbic system - in connection with emotions

Regulation of blood pressure

Short - term regulation

- baroreflex

Middle - term regulation

- humorals regulation

- sympathetic - catecholamines
- RAAS
- ADH

More information – see lectures:Endocrinology

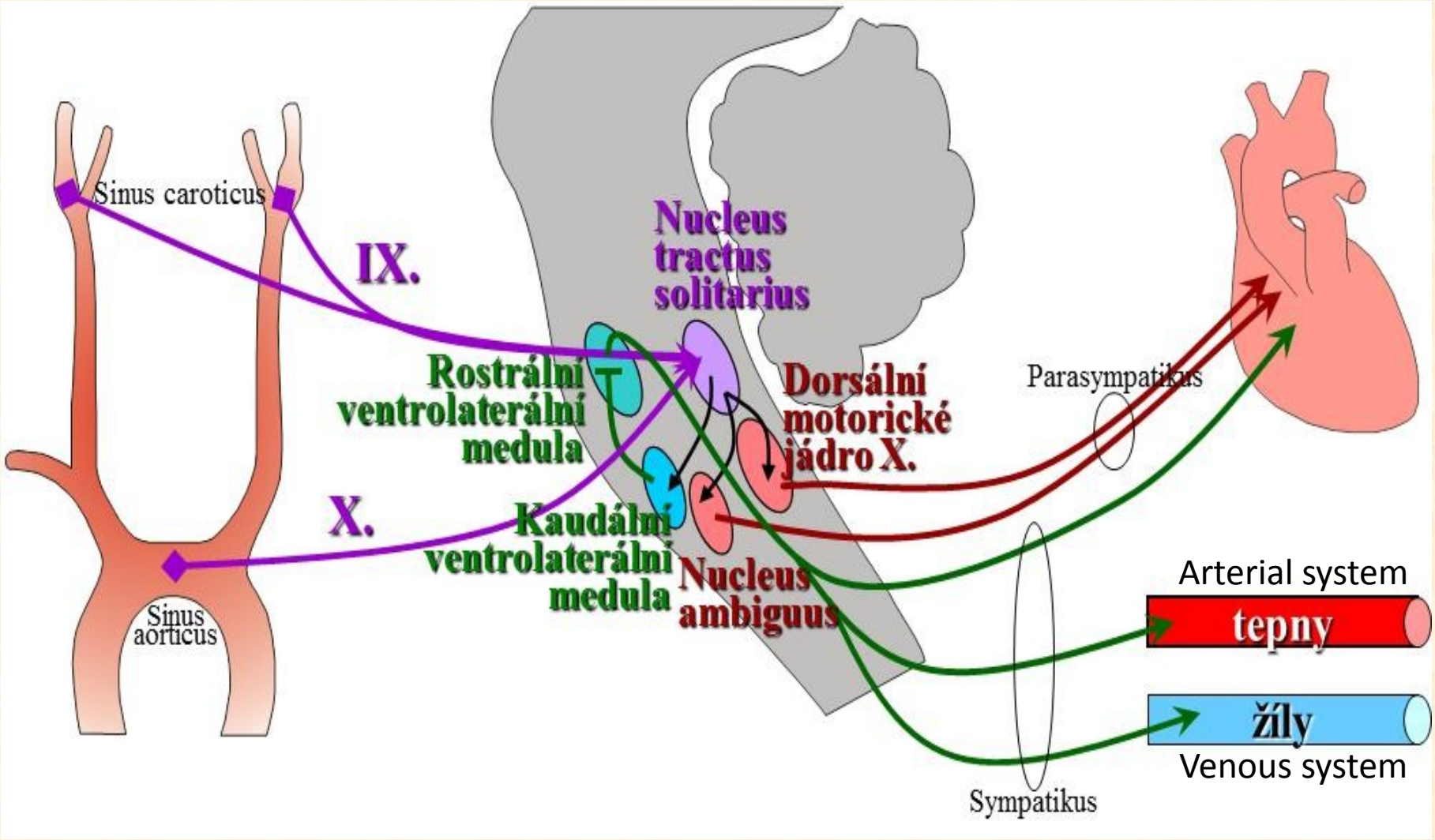
Long - term regulation

- kidney regulation

More information – see lectures:Excretory system

Short term regulation

BAROREFLEX



Source: Závodná E., PhD thesis, 2007

VARIABILITY OF CIRCULATORY PARAMETERS

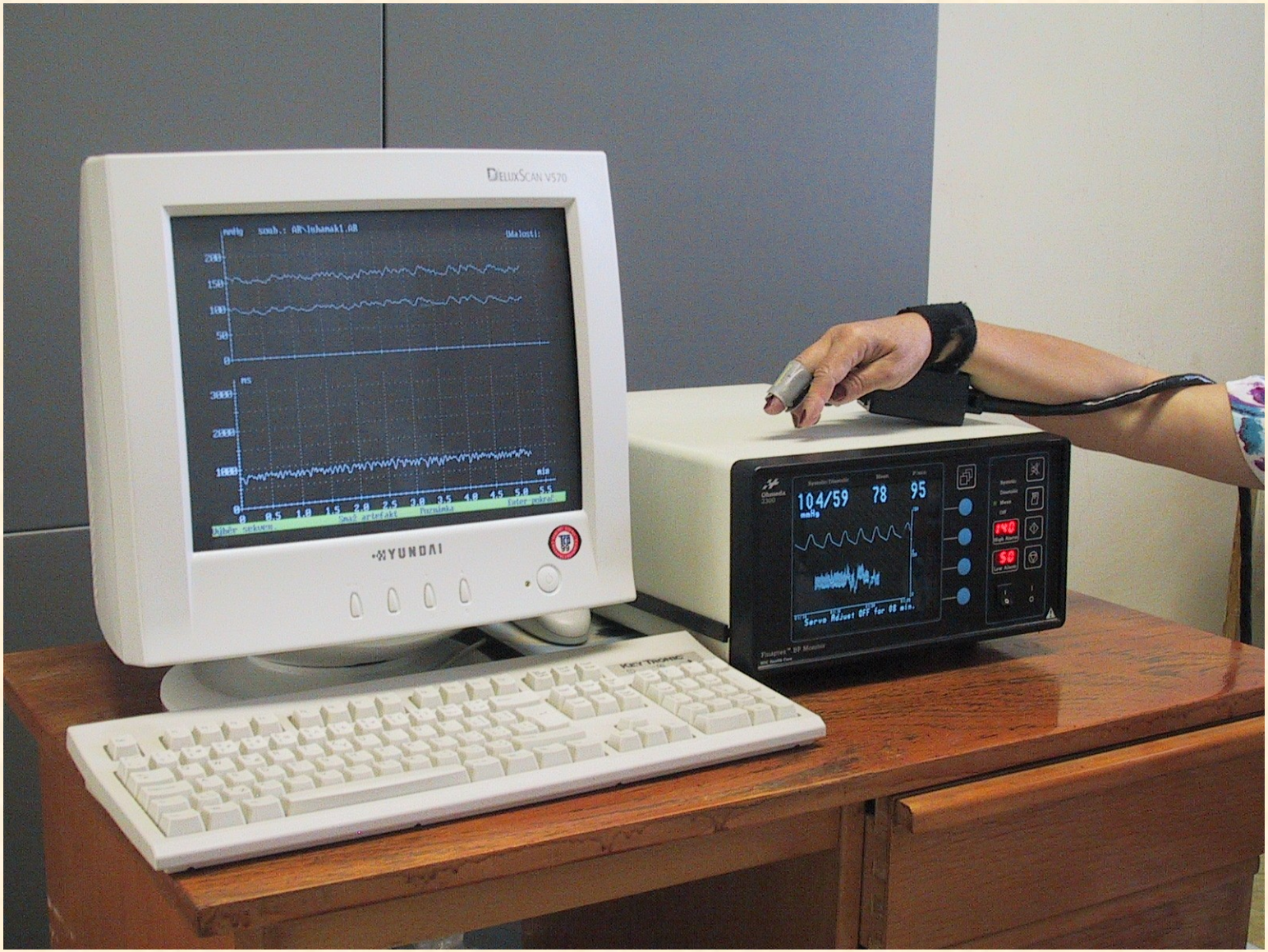
Examples of circulatory parameters:

basic – blood pressure, heart rate, inter-beat intervals
(from ECG record – RR intervals)

Others: cardiac output, stroke volume, periphery resistence
(problems with their measurement)

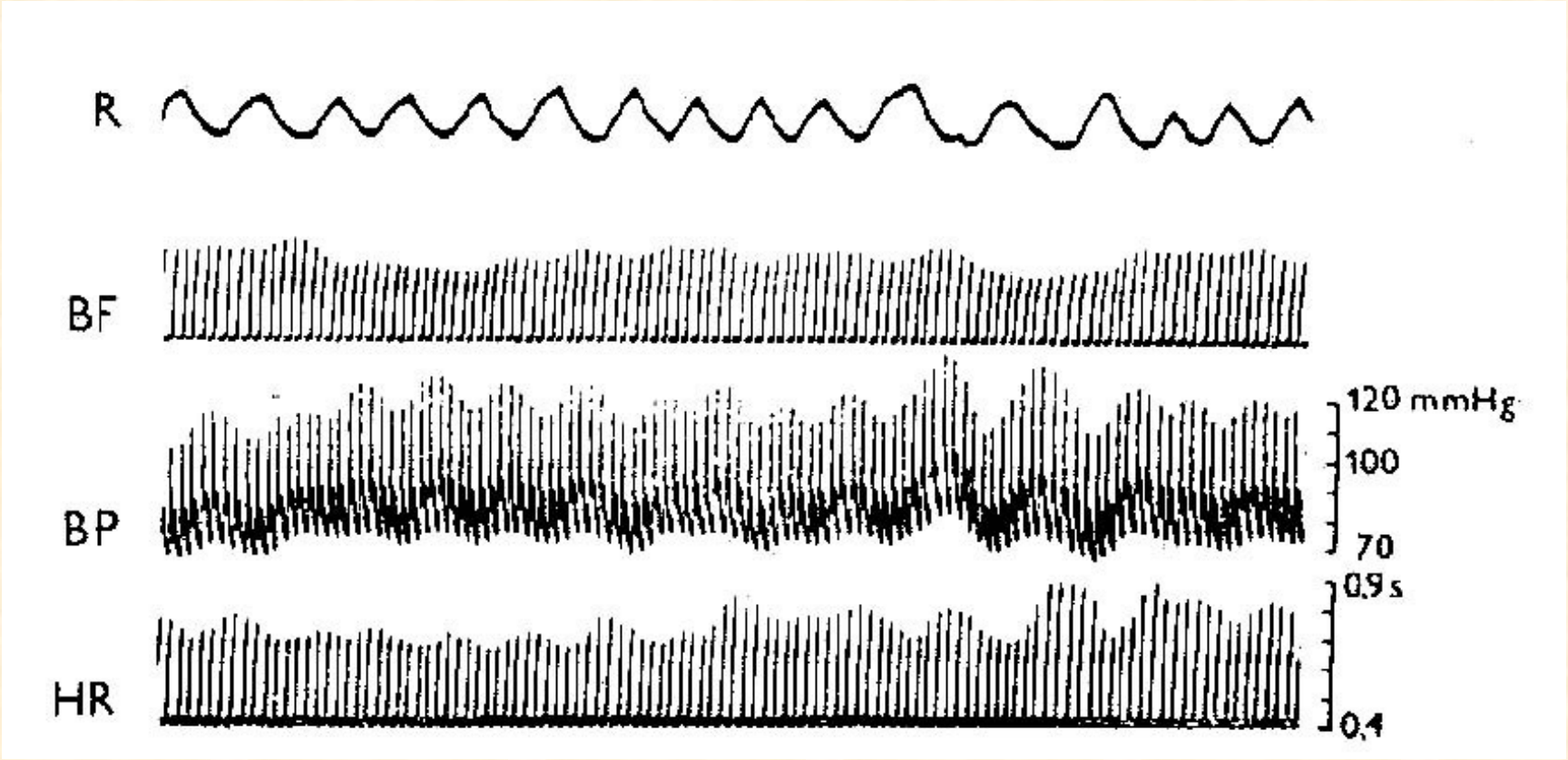
Notice:
More information: selective lectures from physiology (Spectral analysis of blood pressure) or demonstration (Blood pressure measurement, estimation of baroreflex sensitivity)

Finapres (Ohmeda, USA)




Finometr (FMS, Nizozemí)
start / stop
FMS Finometer

Records of circulatory parameters



Sensitivity of baroreflex

Prolongation of pulse intervals (or RR intervals) in miliseconds due to changes of systolic blood pressure about 1 mmHg

Physiology values:

6 – 16 ms/mmHg

Estimation of baroreflex sensitivity

Invasive methods

Bolus injections of vasoactive drugs

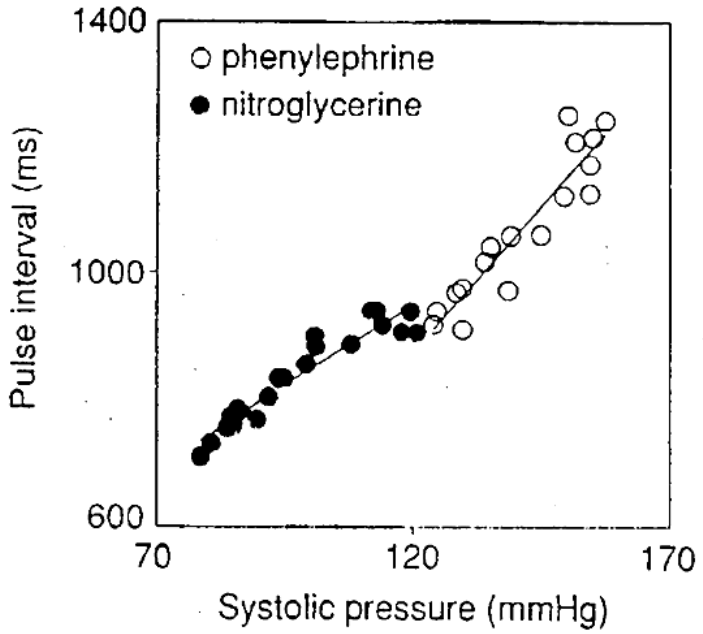
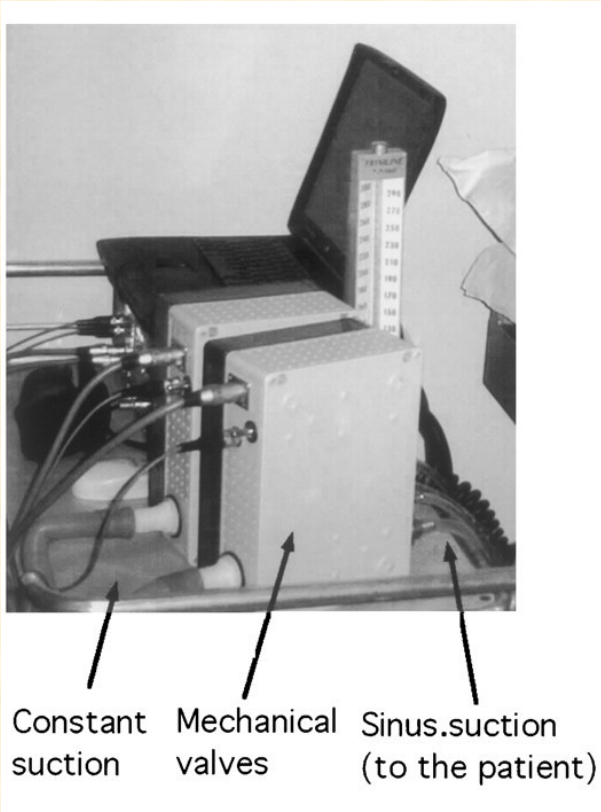
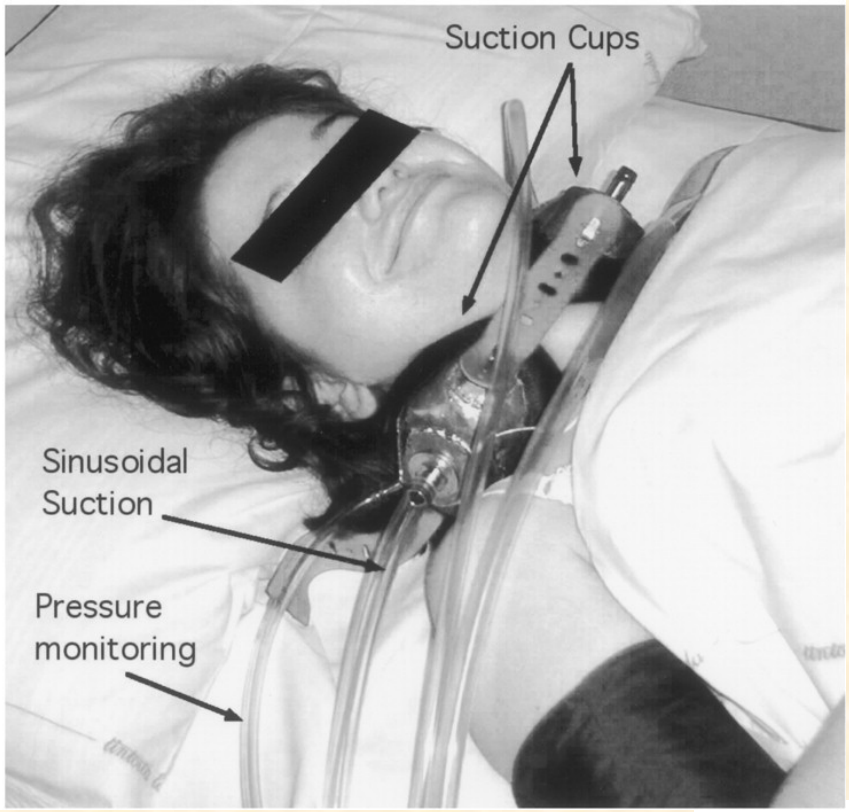


FIG. 5.4. Comparison of R–R interval responses of one subject to intra bolus injections of phenylephrine and nitroglycerine. Adapted with permissio Pickering *et al.* 1972*c*).

Estimation of baroreflex sensitivity

non – invasive technique – neck suction





Furlan R et al. Circulation 2003;108:717-723

American Heart Association
Learn and Live

First article about spectral analysis of BP

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SPECTRAL ANALYSIS OF RESTING VARIABILITY OF SOME CIRCULATORY PARAMETERS IN MAN

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Summary

PEŇÁZ, J., N. HONZÍKOVÁ, B. FIŠER (Dept. Physiol., Fac. Med. J. E. Purkyně Univ., Brno). *Spectral Analysis of Resting Variability of Some Circulatory Parameters in Man.* Physiol. bohemoslov., 27(4): 349—357, 1978.

The blood pressure and finger blood flow were recorded by indirect photoelectric methods, together with the heart rate and respiration, in 13 experimental subjects. The systolic pressure (SP), diastolic pressure (DP) and pulse pressure (PP), the heart rate (HR), the acral (finger) blood flow (BF) and the respirogram (R) were read from 5- and 20-min segments at one-second intervals. Autocorrelation functions were calculated from these values and from these in turn the power spectral densities, cross correlation functions, cross-spectral densities and coherence of the individual pairs of parameters studied.

ACKNOWLEDGEMENTS. The authors wish to thank the staff of the Computer Department of the Faculty of Electrical Engineering, Technical University, Brno, for working out the programmes and carrying out the computations.

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Baroreflex Sensitivity Determined by Spectral Method and Heart Rate Variability, and Two-Years Mortality in Patients After Myocardial Infarction

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PACE, Vol. 23 November 2000, Part II 1965

Determined by Spectral Analysis in Risk Stratification After Myocardial Infarction

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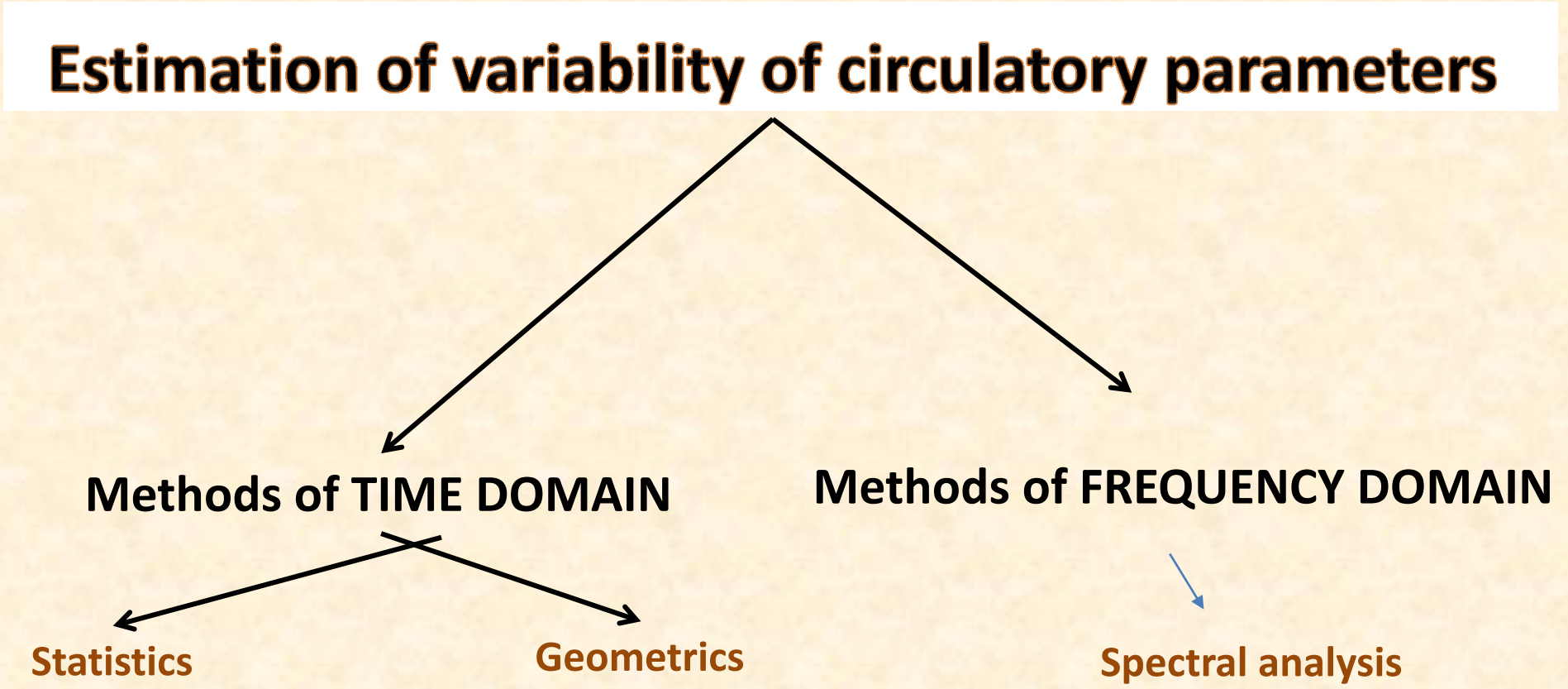
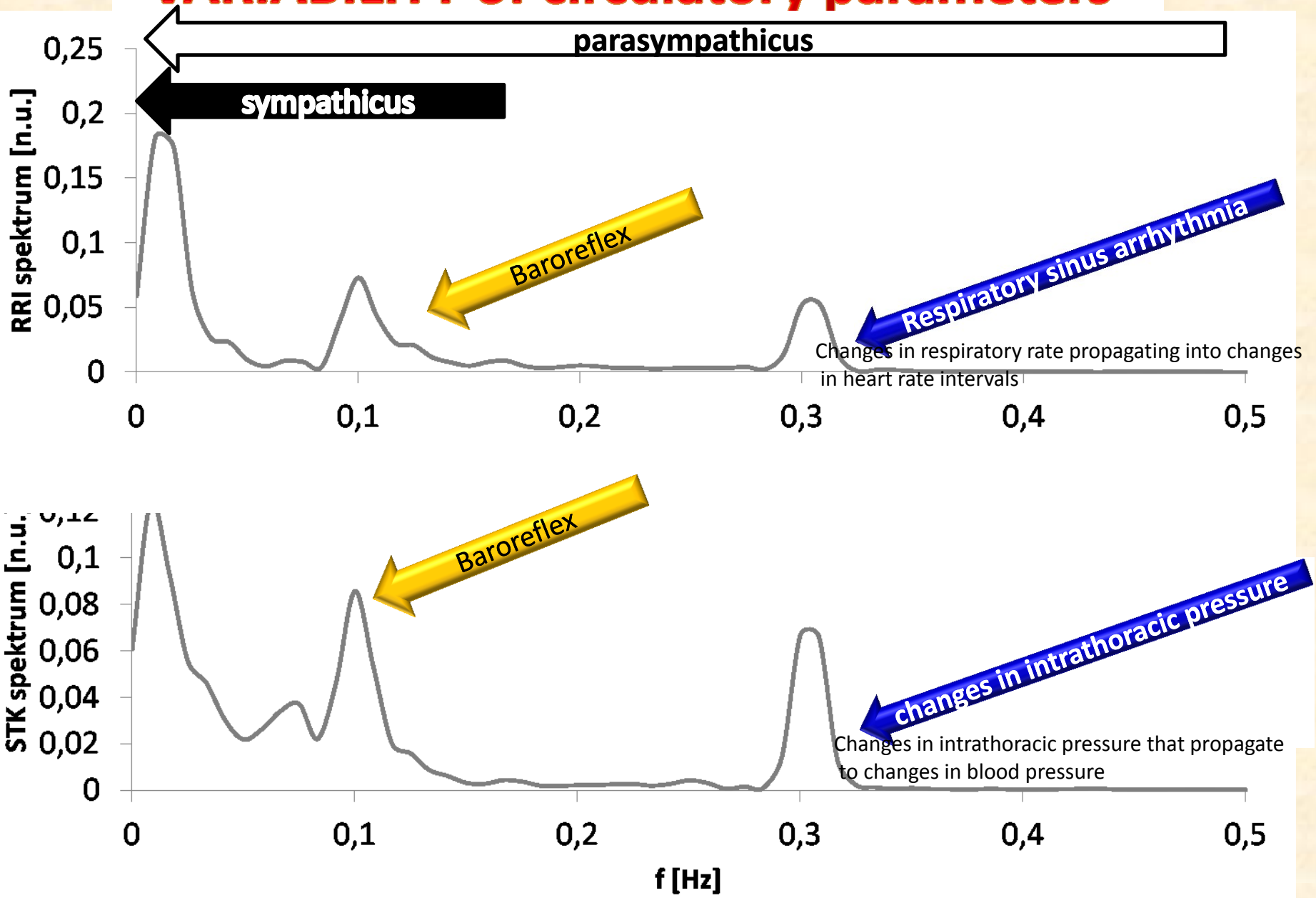
SPONTANEOUS METHODS



VARIABILITY of circulatory parameters



- determination of baroreflex sensitivity remains an indicator of the sympathetic and parasympathetic relationship in the regulation of blood pressure and heart rate in clinical practice

- reduced BRS is found in many diseases: hypertension, diabetes mellitus, metabolic syndrome, in patients after cancer treatment, etc.

- for patients after myocardial infarction, a reduced BRS value below 3ms/mmHg together with a reduced ejection fraction below 40% represents an **increased risk of sudden cardiac death**

Based on a 24-hour ambulatory blood pressure monitoring (24h ABPM)

we can see physiological fluctuations in blood pressure, and blood pressure during the day and night.

See lecture: Blood pressure

Based on a 24-hour ECG recording=Holter monitoring

the parameter is evaluated in clinical practice: **heart rate variability (HRV)** - fluctuations in heart rate during the day and night, the **LF / HF ratio** is determined… it gives information whether a person is more under the influence of sympathetic (LF / HF>1) or parasympathetic (LF / HF<1).

See lecture: Examination of the cardiovascular system