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 vasodilatatation)

- 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

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

- **Blood pressure (BP) – pressure of the blood to the wall of the vessels**

- **Systolic BP, diastolic BP, pulse pressure, mean arterial pressure (MAP)**

BP = CO x R   CO – cardiac output, R – resistance

CO = SV x HR   SV – stroke volume, HR – heart rate

Classification BP values according to office BP

category	Systolic BP	Diastolic BP
	(mmHg)	(mmHg)
optimal	< 120	< 80
normal	120 – 129	80 – 84
high normal pressure	130 – 139	85 – 89
Hypertension – mild – grade 1	140 – 159	90 – 99
Hypertension – moderate-grade 2	160 – 179	100 – 109
Hypertension – severe – grade 3	≥ 180	≥ 110
Isolated systolic hypertension	≥ 140	< 90

According the Guidelines of ESC/ESH 2018

- Definitions of hypertension according to
office, ambulatory, and home blood pressure levels

- Category SBP(mmHg) DBP(mmHg)
- Office BP[a] >_140 and/or >_90
- Ambulatory BP

  Daytime (or awake) mean >_135 and/or >_85

  Night-time (or asleep) mean >_120 and/or >_70

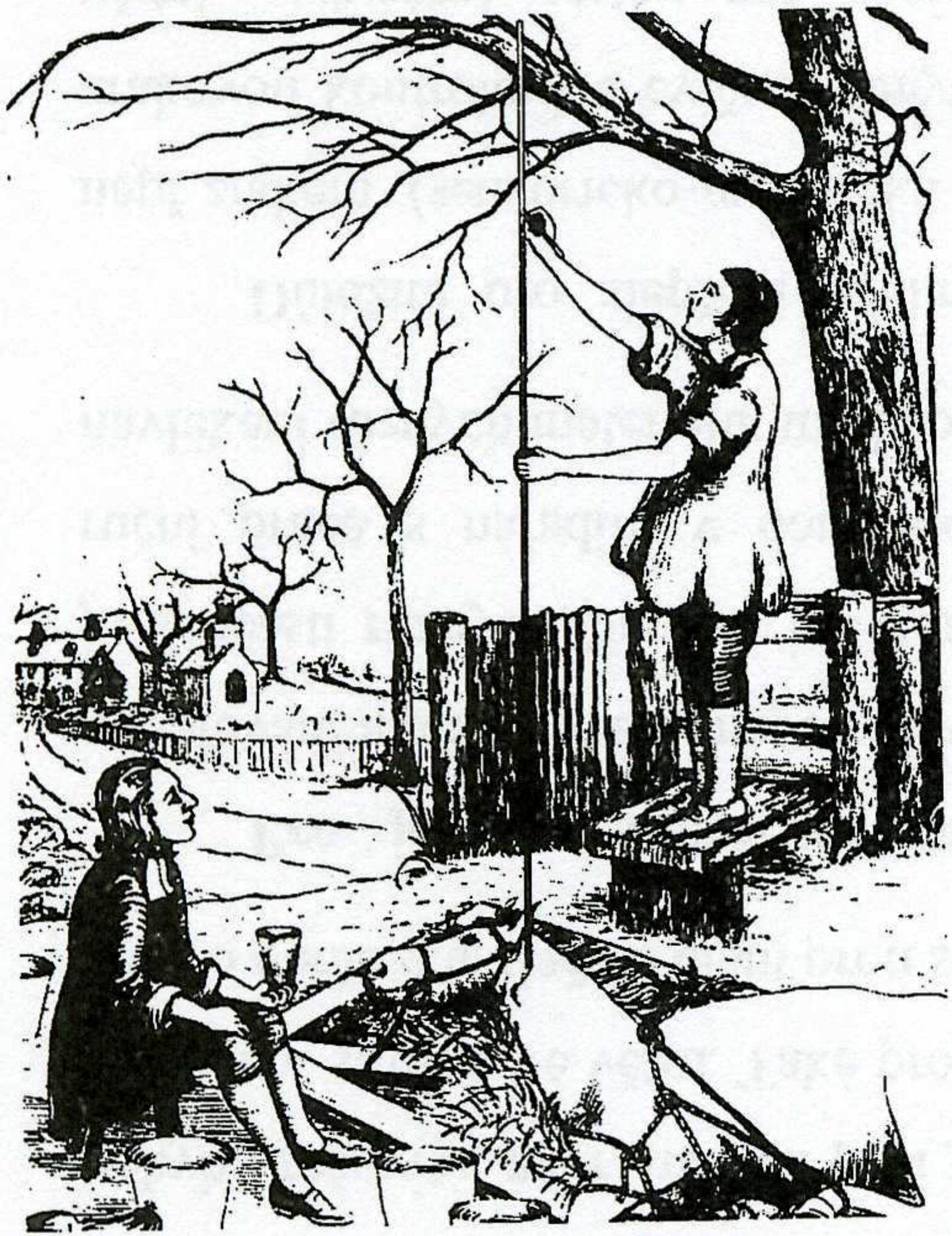
  24 h mean >_130 and/or >_80
- Home BP mean >_135 and/or >_85

- BP = blood pressure; DBP = diastolic blood pressure; SBP = systolic blood
- pressure.
- aRefers to conventional office BP rather than unattended office BP.

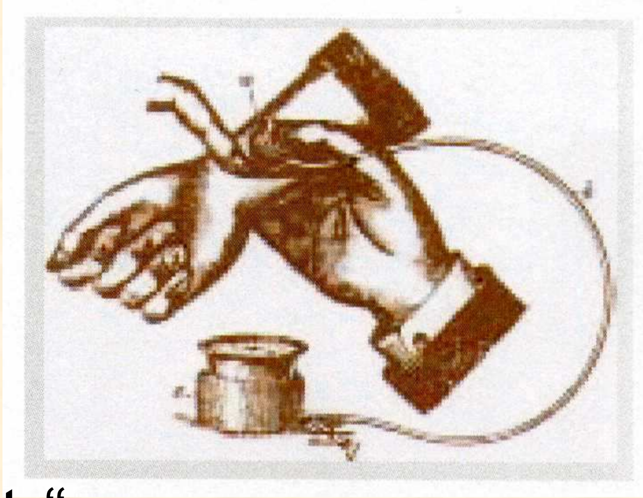
BLOOD PRESSURE MEASUREMENT

- **Direct invasive method**
  – 1726 Stephan Hales – horse
  – Today – during catetrisation

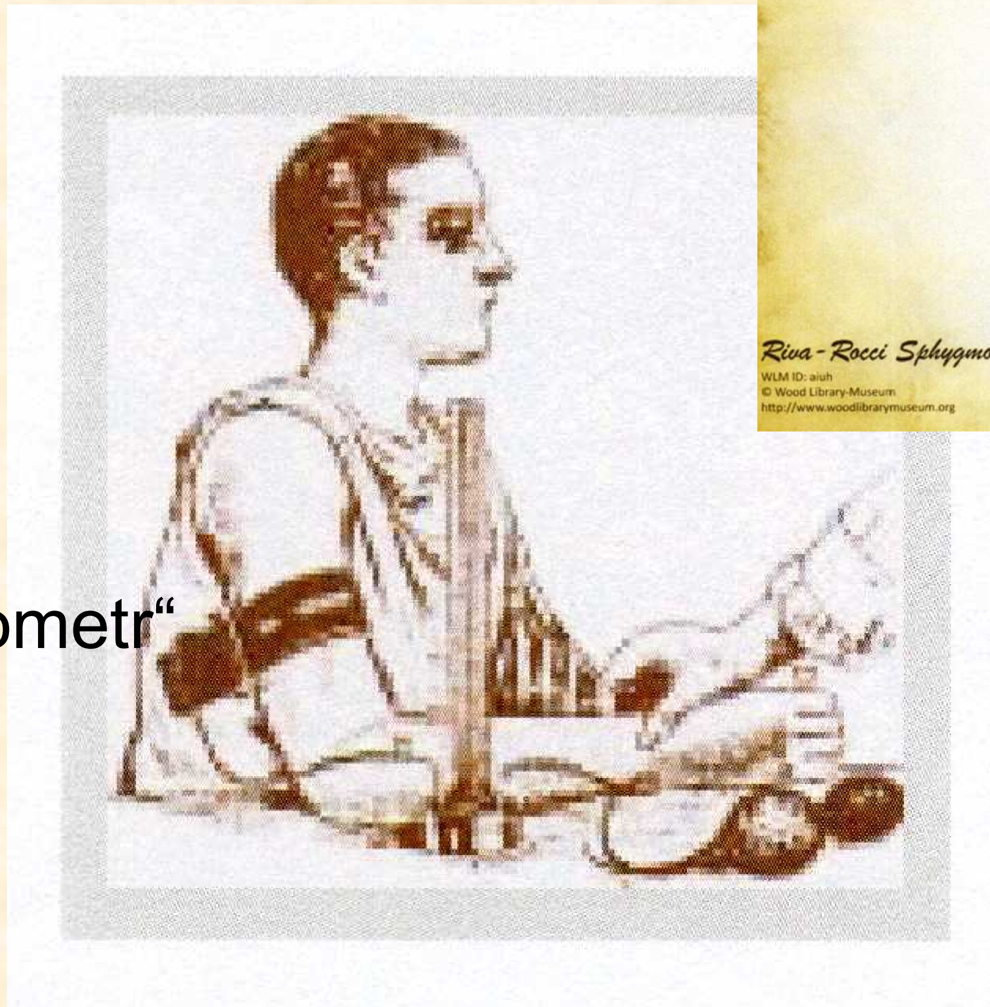
- **Indirect non-invasive measurement**
  - palpation method
  - Auscultation method
  - Oscilometric method



Palpatory methods



An Austrian physician
Von Basch
„aneroid sfygmomanometr“
Balloon in the wrist
1876

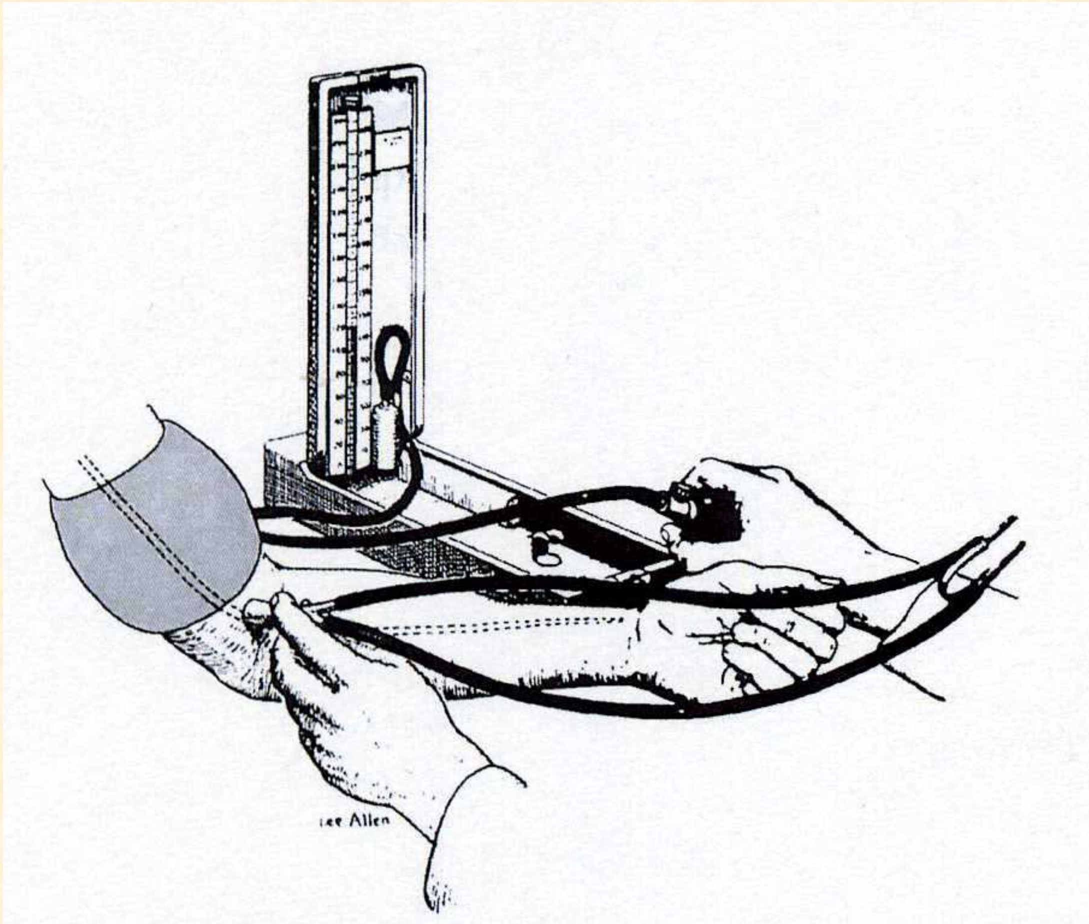


Italian physician
Riva Rocci
„mercury sfygmomanometr“
The cuff on the arm
1896

Auskultatory method

A Russian army surgeon
Nikolai Korotkoff
1904

„mercury sfygmomanometr“
The cuff on the arm
Stethoscope at the elbow



The size of the cuff in adults

Tab. 7.2 Doporučená šířka manžety tlakoměru u dospělých podle obvodu paže vyšetřovaného

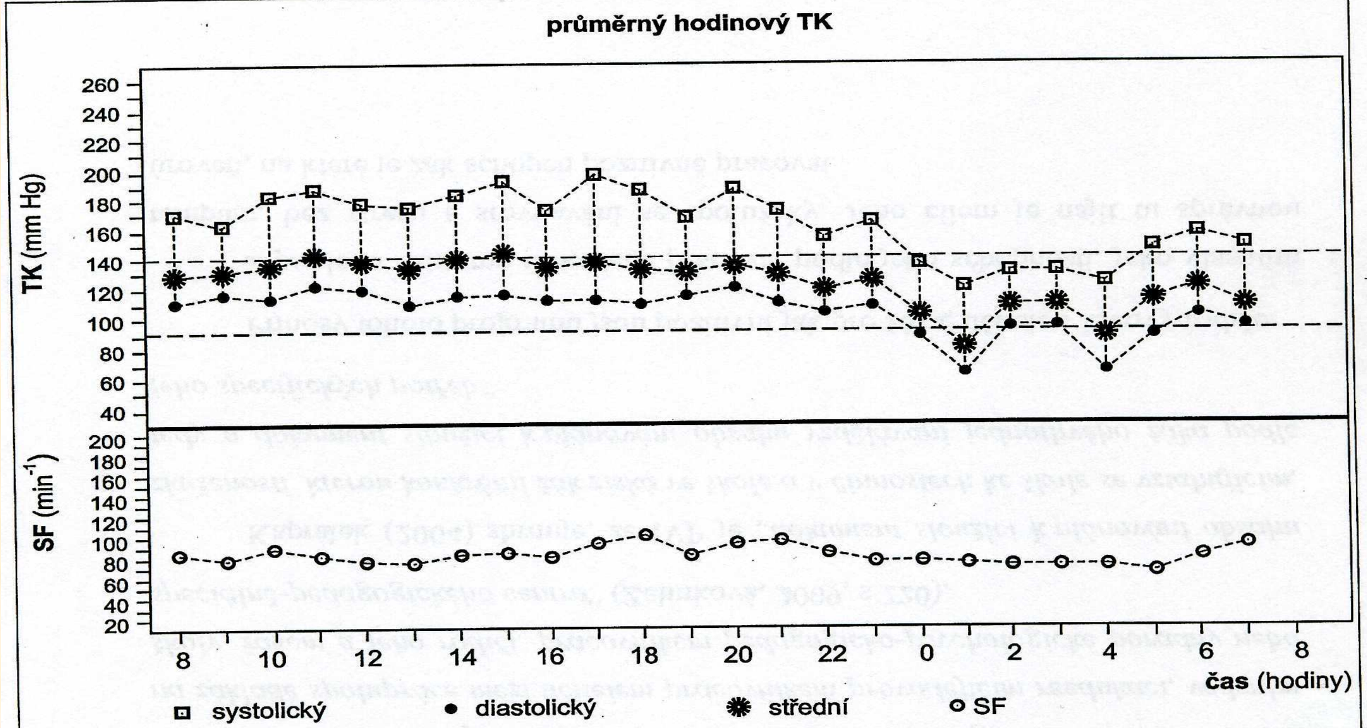
	kategorie manžety	obvod končetiny (cm)	šířka × délka gumového vaku (cm)
Small adult	malá dospělá	22–26	10 × 24
Adult	dospělá	27–34	13 × 30
Large	velká dospělá	35–44	16 × 38
Tight cuff	stehenní dospělá	45–52	20 × 42

Špinar, J. a kol. Propedeutika a vyšetřovací metody vnitřních nemocí, 2008

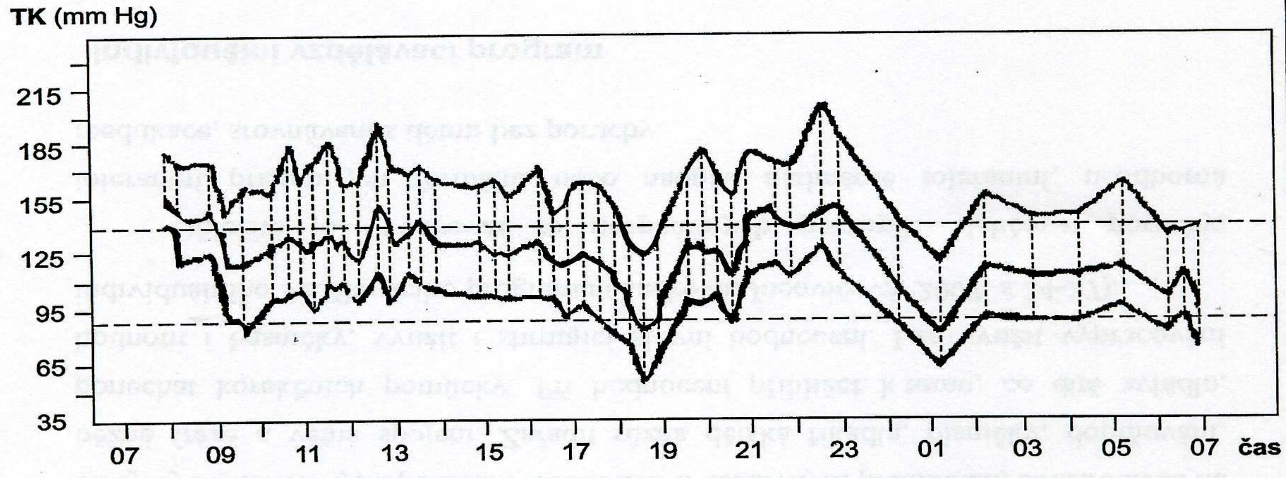
Ambulatory blood pressure monitoring

- **Circadial rhythm** – fluctuation during 24 h
- The highest values – the morning, 6 –10 a.m.
  - the afternoon, 4 – 6 p.m.
- The lowest values – 3 – 4 a.m.

- **Diurnal rhythm** – differences between day – night
- Dippers - nondippers


průměrný hodinový TK
TK (mm Hg)
260
240
220
200
180
160
140
120
100
80
60
40
SF (min^{-1})
200
180
160
140
120
100
80
60
40
20
8
10
12
14
16
18
20
22
0
2
4
6
8
čas (hodiny)
systolický
diastolický
střední
SF

B


TK (mm Hg)
215
185
155
125
95
65
35
07
09
11
13
15
17
19
21
23
01
03
05
07
čas

C

- Record during 24 h or 48h or 7 days

- Dif.dg. : **white coat hypertension**
- **Control of treatment of hypertension**

- **Evaluation:**
- Mean values during 24 h: less than 125/80
- Mean values during day period:less than 135/85
- Mean values during night period:less than 120/70
- **Hypertension:**
  - **More than 40% values above 140/90 at day, 120/80 at night**

Regulation of blood pressure

Short - term regulation

- baroreflex

Middle - term regulation

- humorals regulation

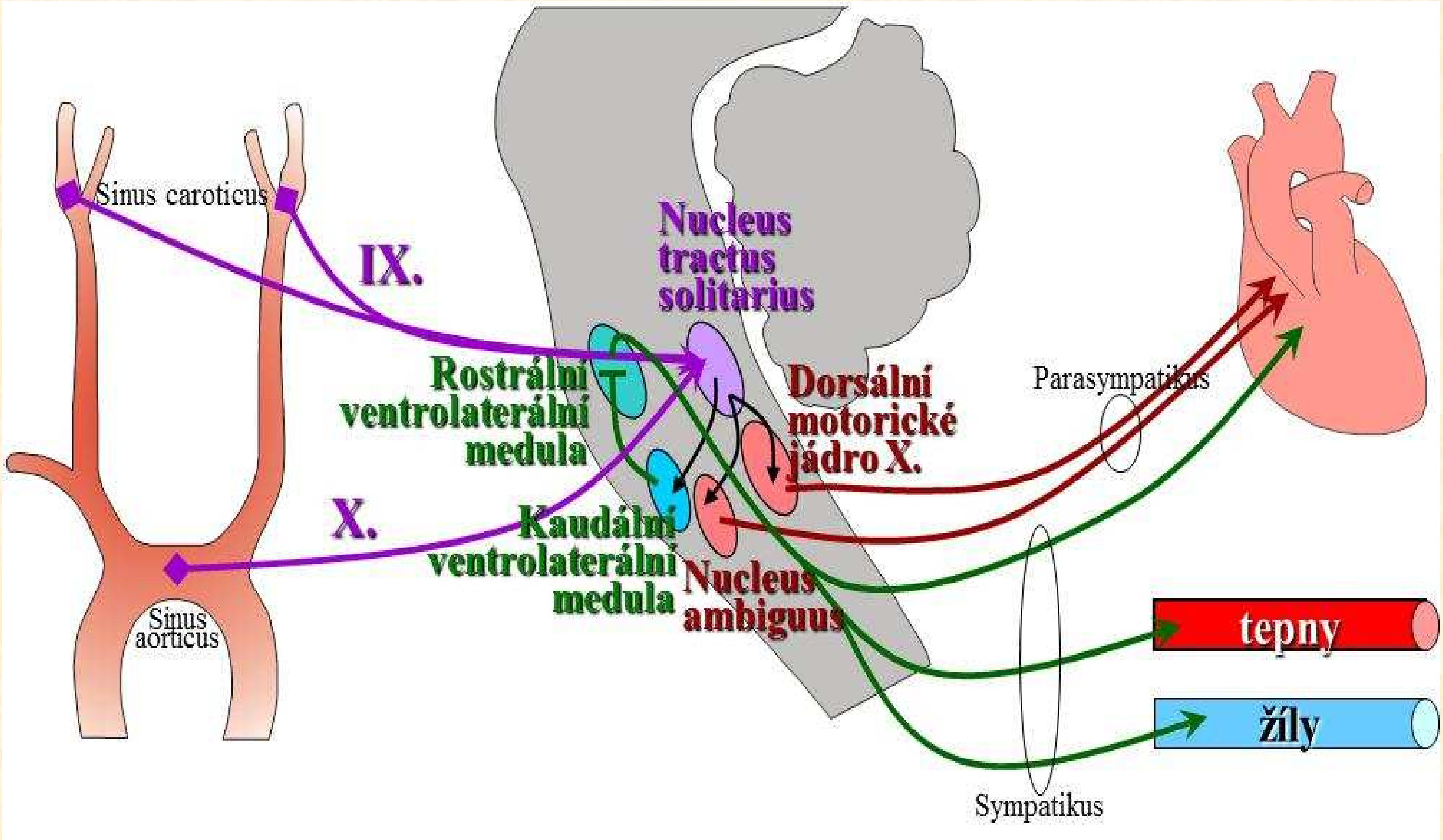
- sympathetic - catecholamines
- RAAS
- ADH

Long – term regulation

- kidney regulation

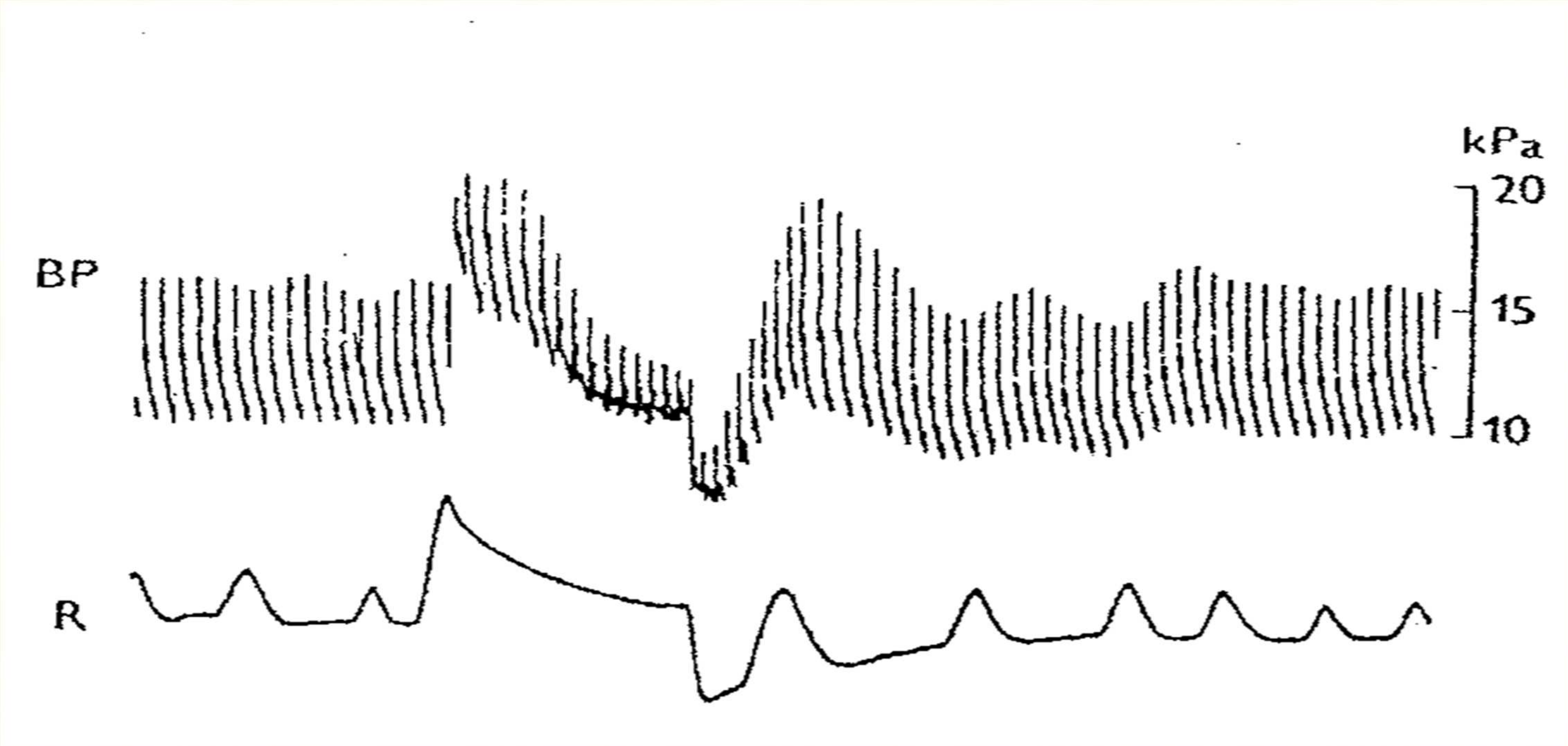
Short term regulation

BAROREFLEX



Stanovení citlivosti baroreflexu

Valsalvův manévr



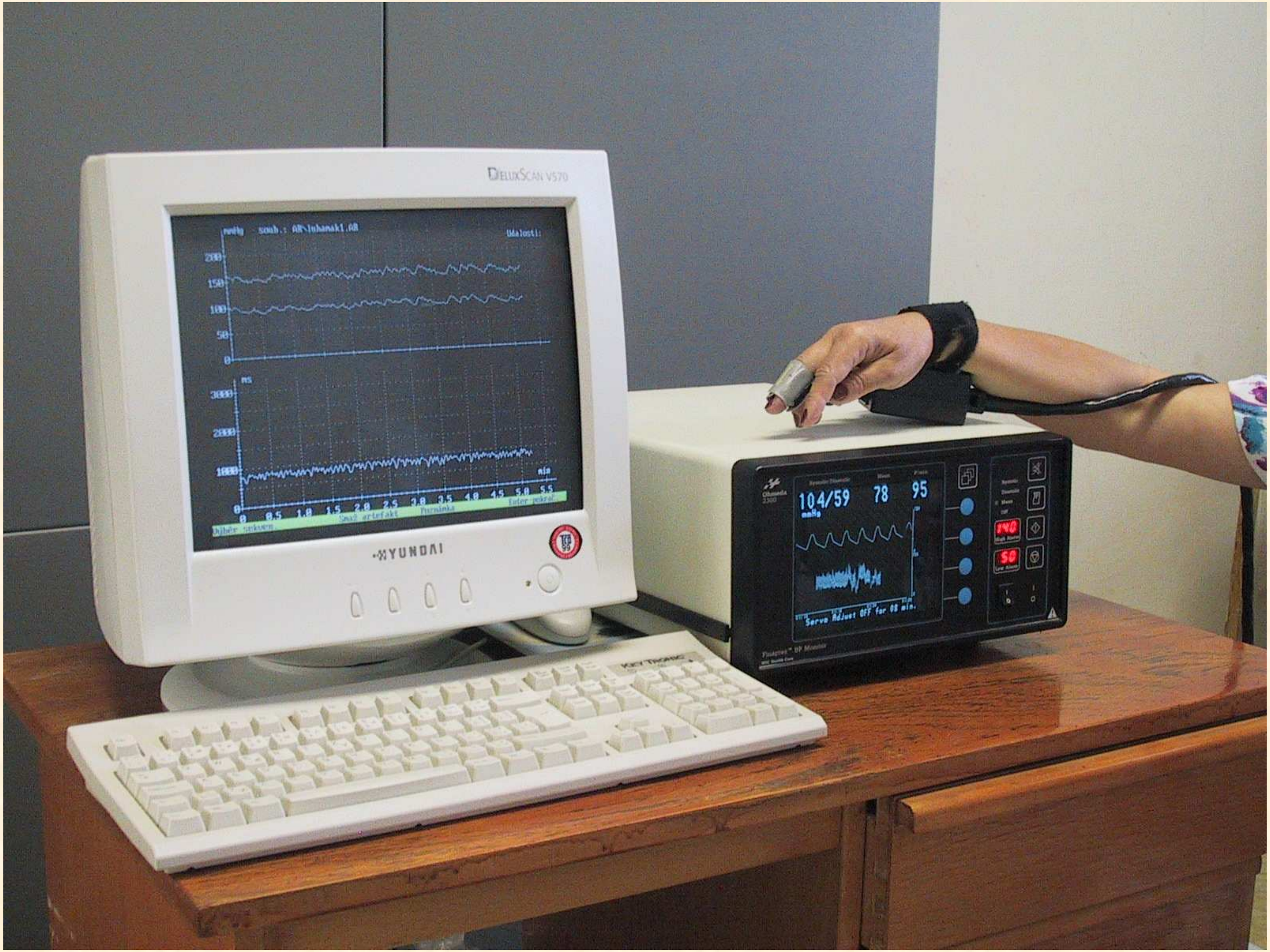
Ganong WF, 2005

Noninvasive continuously beat-to-beat measurement of finger arterial pressure

- Prof. Jan Peňáz, MD, PhD
- Teacher and researcher on the Department of Physiology, Masaryk university, Brno
- Patent 1969


FC

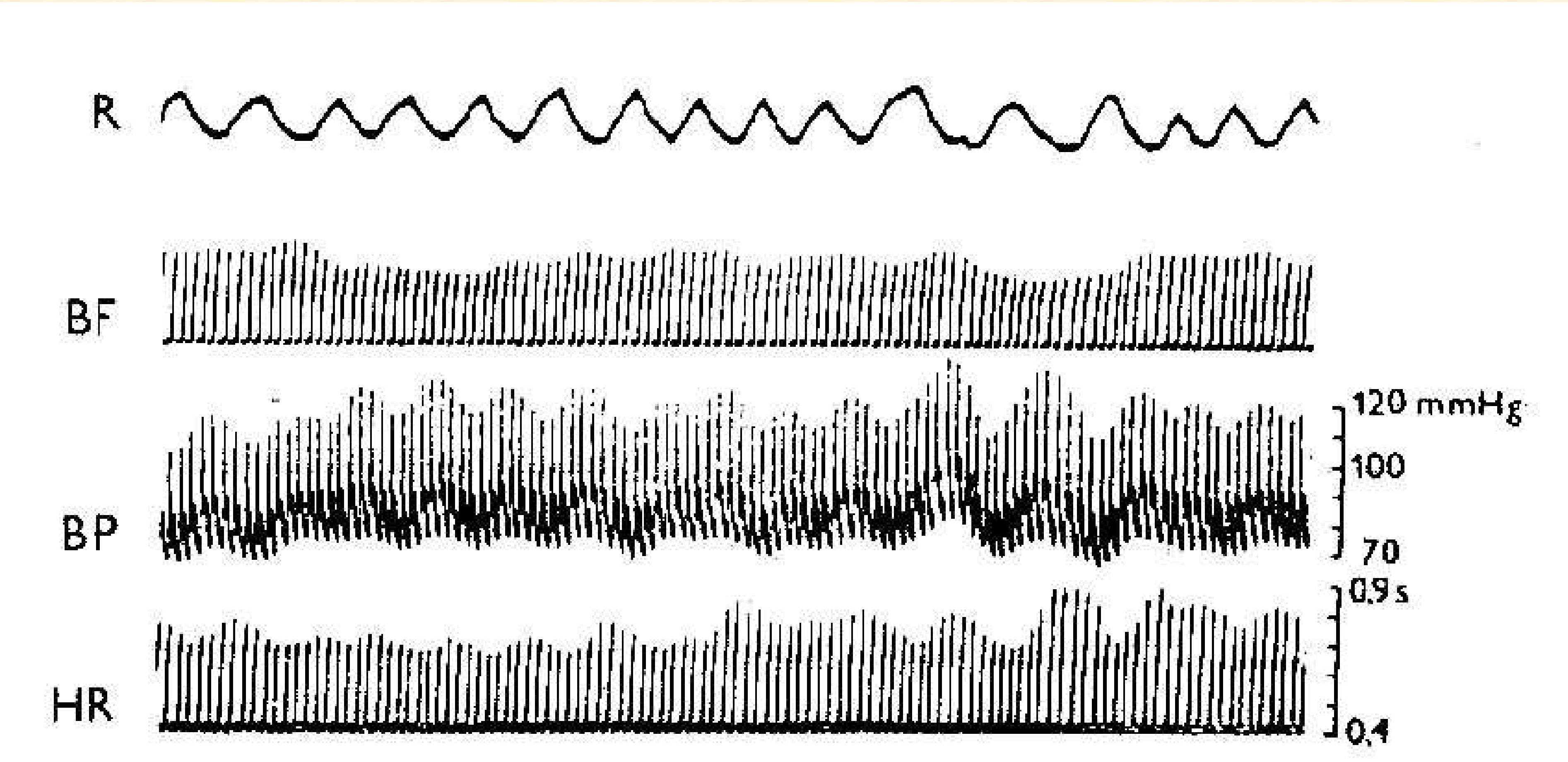
Finapres (Ohmeda, USA)



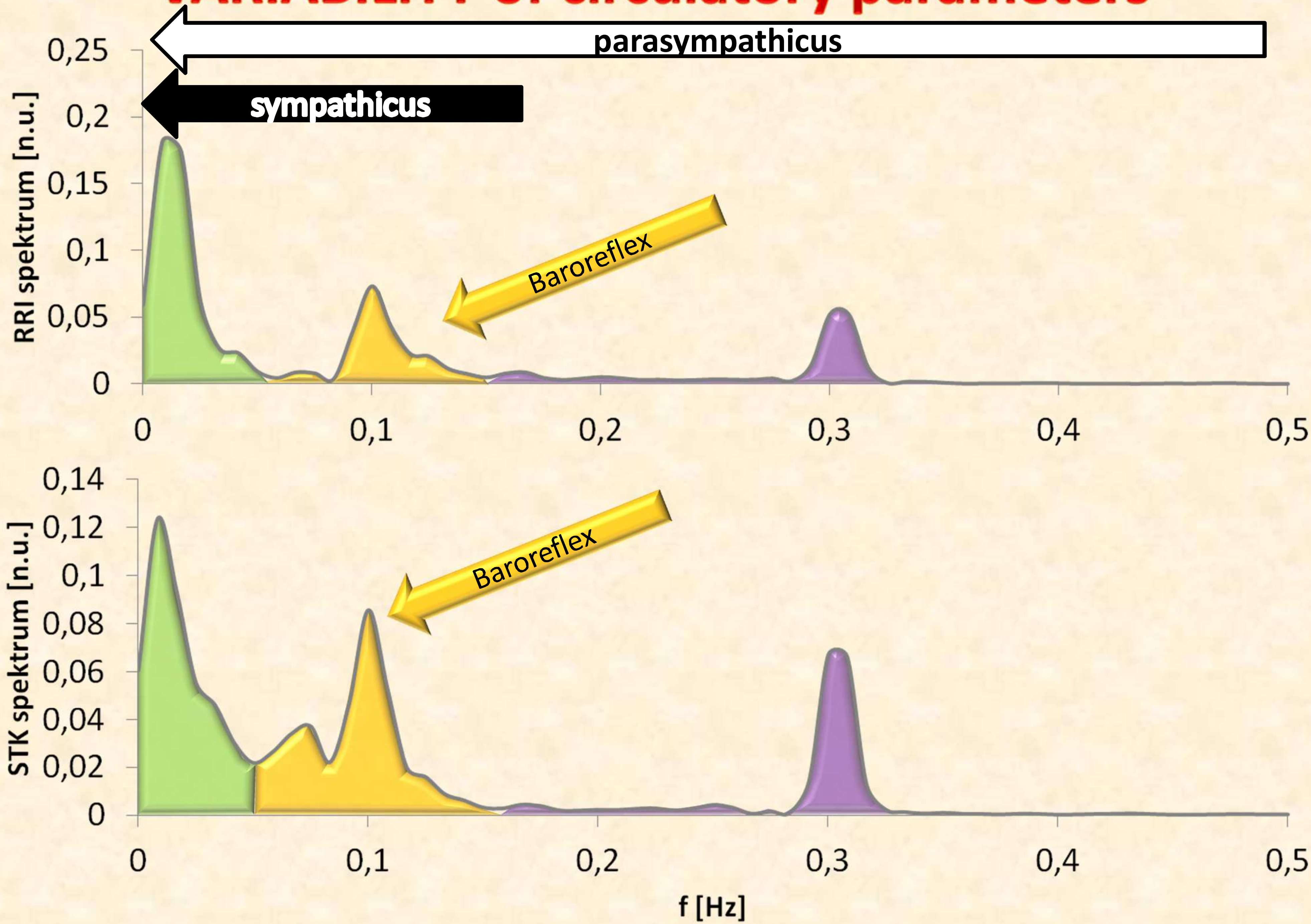
Finometr (FMS, Nizozemí)

- We need than **pressure in the cuff corresponded to the pressure of the digital artery**
- **Method: photopletysmography**
- Recorded photoelectric plethysmogram
- The new term: **Transmural pressure** – Pt (the pressure across the wall of the artery)
- BP, Pc (pressure in cuff), Pt
- We estimated: **BP=Pc - - - Pt=0** - - - photoplethysmogram registered the highest amplitude of oscilation --- we measure the **MAP**
- Step by step increase of Pc, in the moment of the highest amplitude – **feed-back loop** started for obtained(keeping) the constant volume of the finger

Records of circulatory parameters



VARIABILITY of circulatory parameters



Classification BP values according to office BP

category	Systolic BP	Diastolic BP
	(mmHg)	(mmHg)
optimal	< 120	< 80
normal	120 – 129	80 – 84
high normal pressure	130 – 139	85 – 89
Hypertension - mild	140 – 159	90 – 99
Hypertension - moderate	160 – 179	100 – 109
Hypertension - severe	≥ 180	≥ 110
Isolated systolic hypertension	≥ 140	< 90

According the Guidelines of ESC/ESH 2018

- Definitions of hypertension according to
office, ambulatory, and home blood pressure levels

- Category SBP(mmHg) DBP(mmHg)
- Office BP[a] >_140 and/or >_90
- Ambulatory BP

  Daytime (or awake) mean >_135 and/or >_85

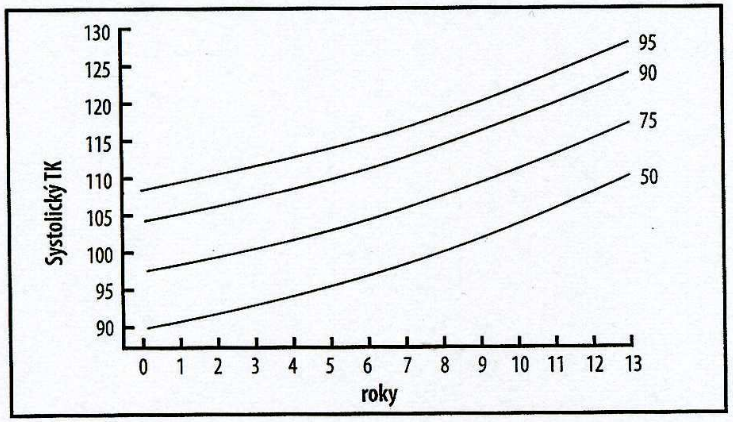
  Night-time (or asleep) mean >_120 and/or >_70

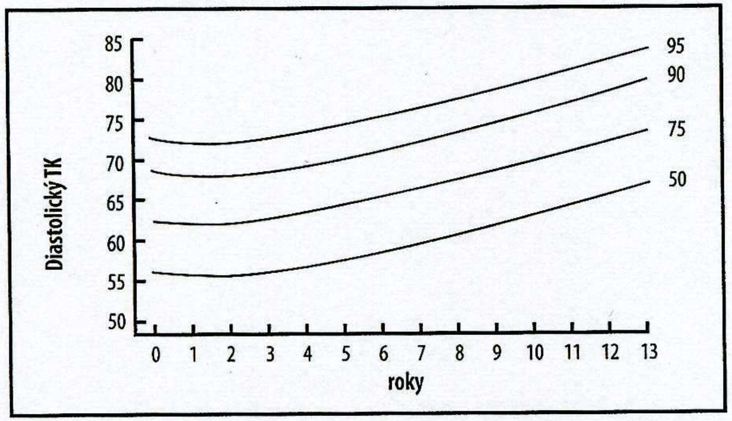
  24 h mean >_130 and/or >_80
- Home BP mean >_135 and/or >_85

- BP = blood pressure; DBP = diastolic blood pressure; SBP = systolic blood
- pressure.
- aRefers to conventional office BP rather than unattended office BP.

Percentilové grafy krevního tlaku u chlapců

od 1 roku do 13 let



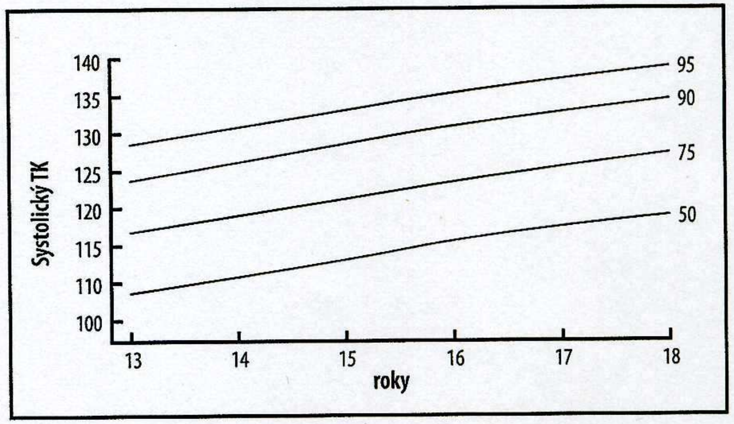


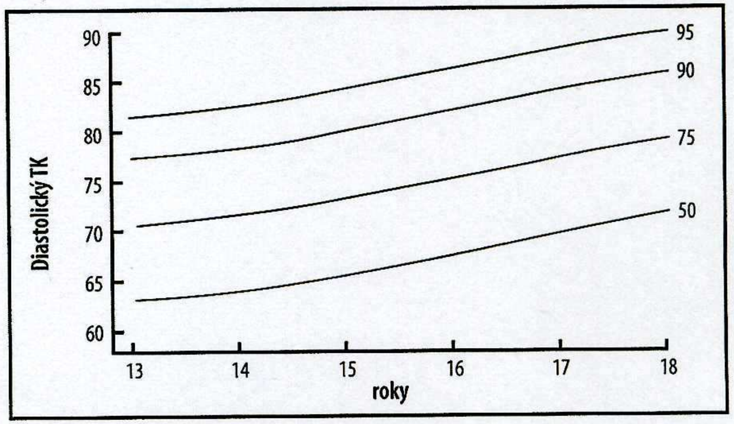
90. percentil

Systolický TK	105	106	107	108	109	111	112	114	115	117	119	121	124
Diastolický TK	69	68	68	69	69	70	71	73	74	75	76	77	79
Výška v cm	80	91	100	108	115	122	129	135	141	147	153	159	165
Váha v kg	11	14	16	18	22	25	29	34	39	44	50	55	62

Percentilové grafy krevního tlaku u chlapců

od 13 do 18 let





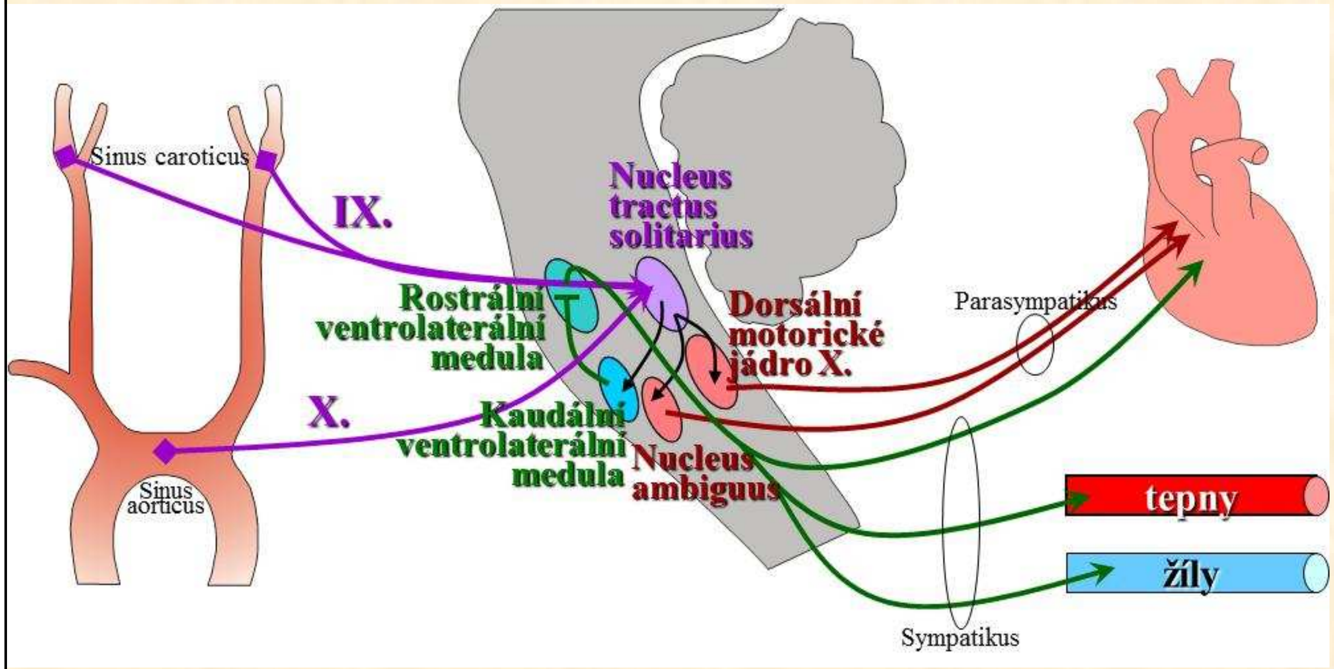
90. percentil

Systolický TK	124	126	129	131	134	136
Diastolický TK	77	78	79	81	83	84
Výška v cm	165	172	178	182	184	184
Váha v kg	62	68	74	80	84	86

Zdravotní a očkovací průkaz dítěte a mladistvého, 2011

Krevní tlak

- bezprostředně po narození je vysoký:
  - poporodní stres – vyplavení katecholaminů a kortizolu
- po 1.dnu se ustálí 70/50 mmHg:
  - otevření pulmonálního a intestinálního řečiště
- další mírný vzestup až k hodnotám pro dospělé v období puberty:
  - postupné dozrávání regulačních mechanismů
  - stimulace z vnějšího prostředí



Sinus caroticus
IX.
X.
Sinus aorticus
Nucleus tractus solitarius
Rostrální ventrolaterální medula
Kaudální ventrolaterální medula
Dorsální motorické jádro X.
Nucleus ambiguus
Parasympatikus
Sympatikus
tepny
žíly

Estimation of baroreflex sensitivity

Invasive methods

Bolus injections of vasoactive drugs

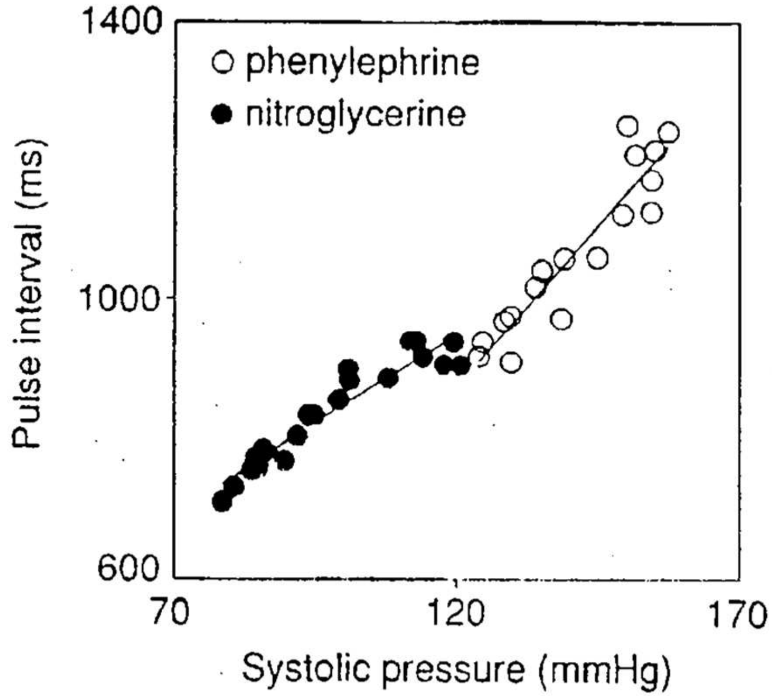
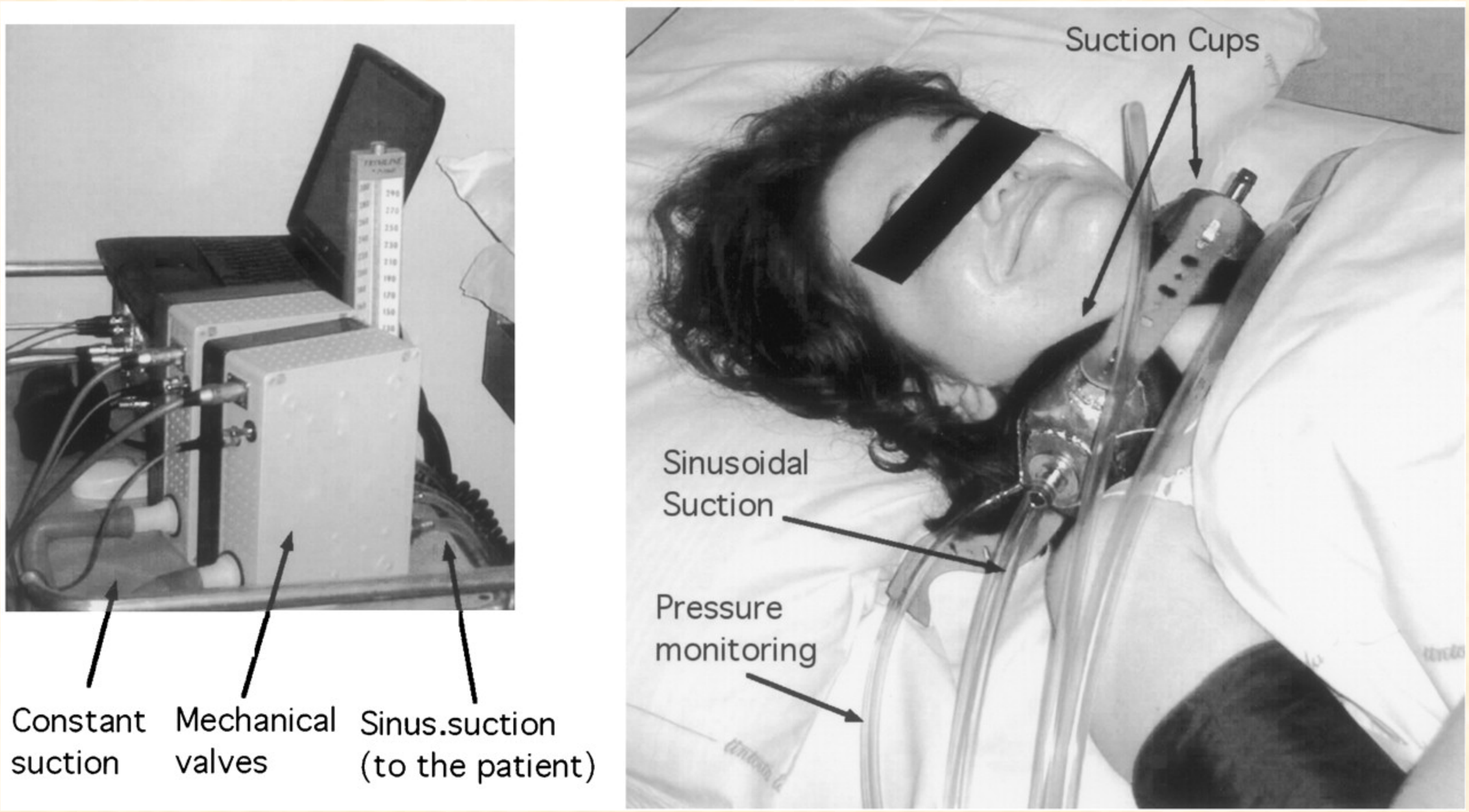


FIG. 5.4. Comparison of R–R interval responses of one subject to intra bolus injections of phenylephrine and nitroglycerine. Adapted with permissio Pickering *et al.* 1972*c*).

Estimation of baroreflex sensitivity

non – invasive technique – neck suction

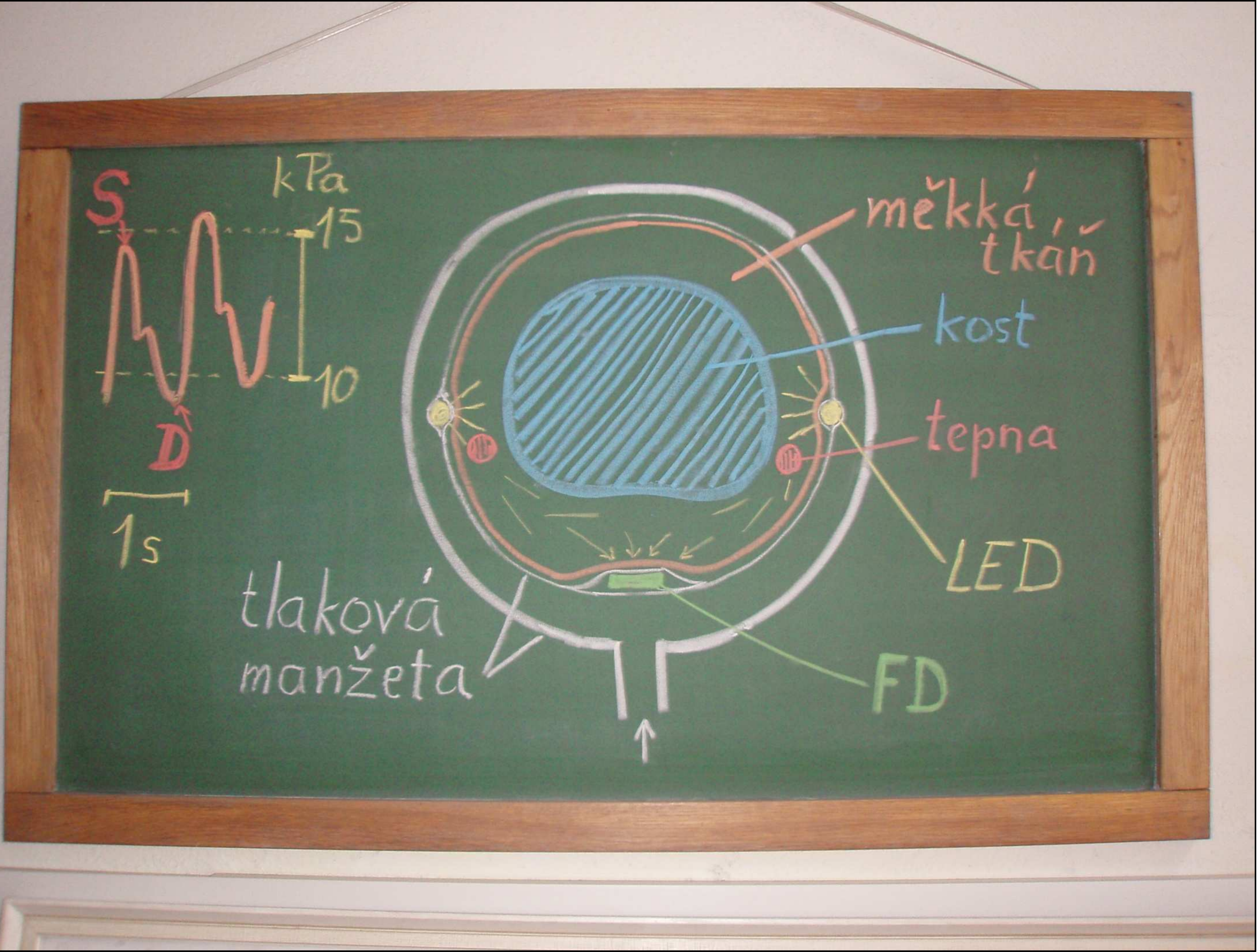


Furlan R et al. Circulation 2003;108:717-723

American Heart Association
Learn and Live

Kontinuální neinvazivní měření tep po tepu - Peňázova metoda

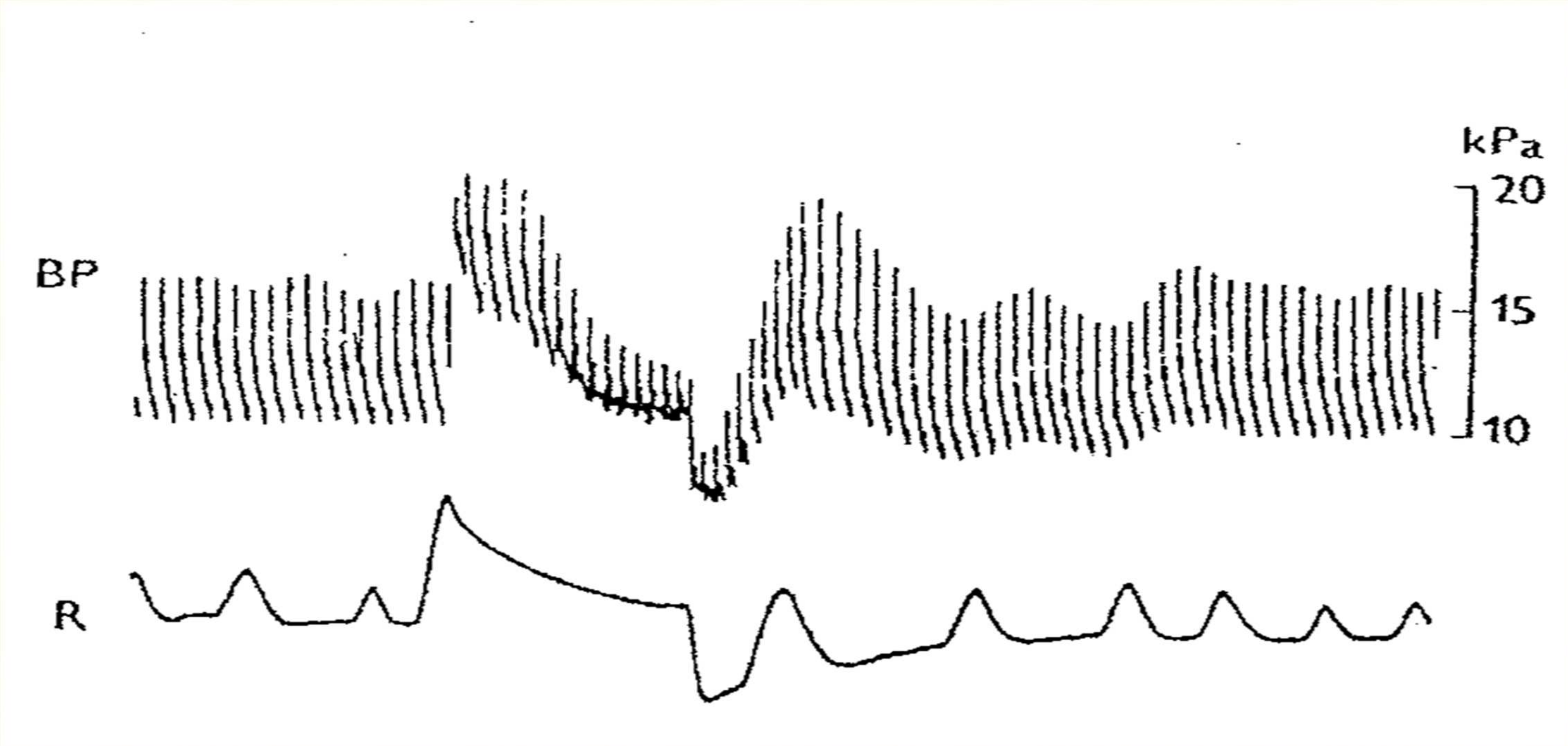
- Profesor MUDr. Jan Peňáz, CSc.
- Fyziologický ústav LF MU
- Čs. patent z roku 1969



S
kPa
15
10
D
1s
měkká
tkáň
kost
tepna
LED
FD
tlaková
manžeta

Stanovení citlivosti baroreflexu

Valsalvův manévr



Ganong WF, 2005

První spektrální analýza krevního tlaku u člověka

Vol. 27 (1978) PHYSIOLOGIA BOHEMOSLOVACA Fasc. 4

SPECTRAL ANALYSIS OF RESTING VARIABILITY OF SOME CIRCULATORY PARAMETERS IN MAN

J. PEŇÁZ, N. HONZÍKOVÁ, B. FIŠER

Department of Physiology, Faculty of Medicine, J. E. Purkyně University, Brno

Received June 16, 1976

Summary

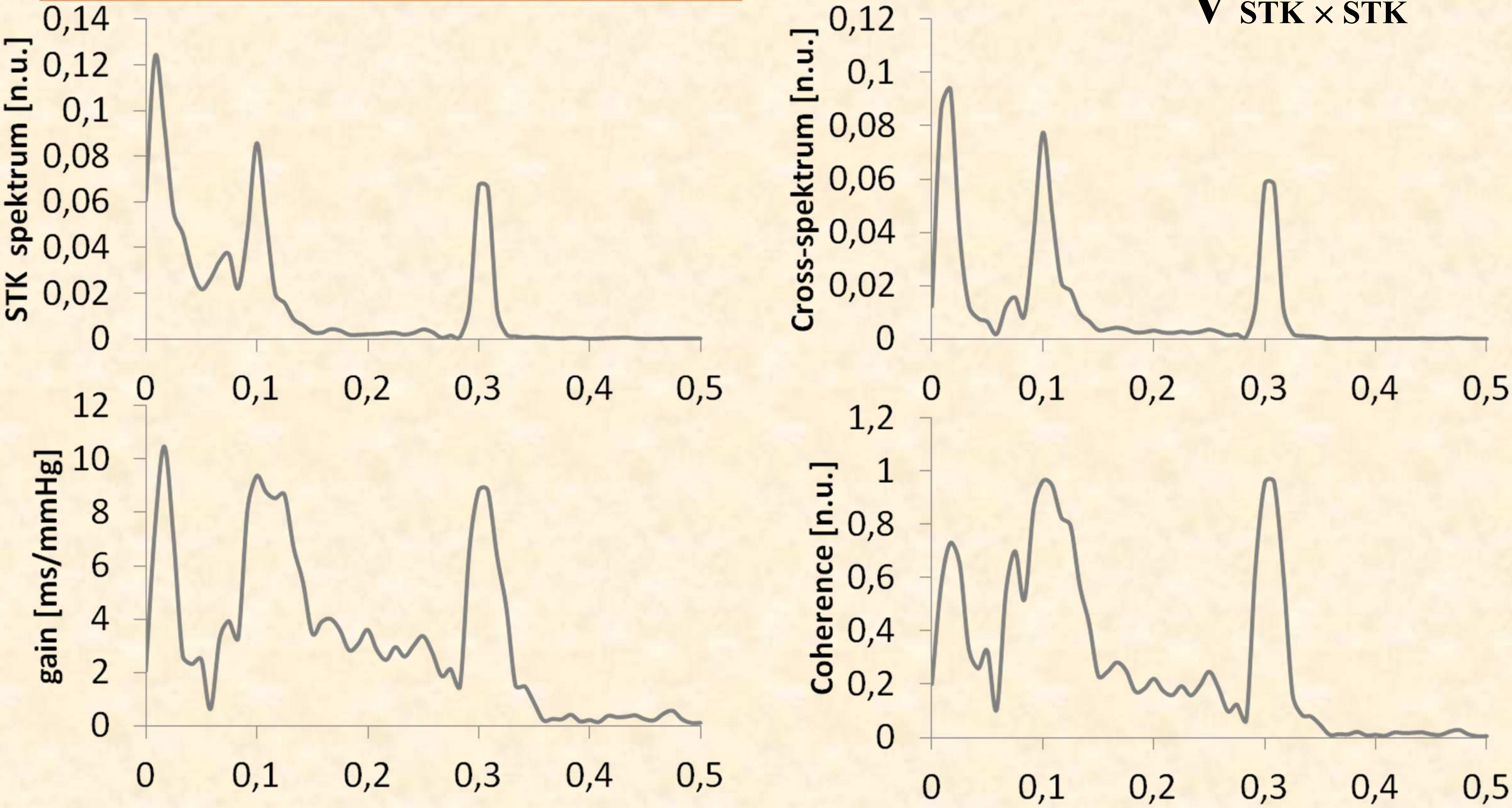
PEŇÁZ, J., N. HONZÍKOVÁ, B. FIŠER (Dept. Physiol., Fac. Med. J. E. Purkyně Univ., Brno). *Spectral Analysis of Resting Variability of Some Circulatory Parameters in Man.* Physiol. bohemoslov., 27(4): 349—357, 1978.

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.

CITLIVOST BAROREFLEXU
- Vzájemná spektrální analýza

$$BRS = \frac{V_{STK \times SI}}{V_{STK \times STK}}$$



Sensitivity of baroreflex

Prolongation of RR intervals in ms due to changes of systolic blood pressure about 1 mmHg

Physiology values:

6 – 16 ms/mmHg

Variabilita v krevním oběhu a BRS – ukazatelé rizika srdeční smrti po infarktu myokardu

Physiol. Res. 49: 643-650, 2000

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

N. HONZÍKOVÁ[1], B. SEMRÁD[2], B. FIŠER[1], R. LÁBROVÁ[2]

[1]*Department of Physiology, Faculty of Medicine and* [2]*First Department of Medicine, Faculty of Medicine, Masaryk University, Brno, Czech Republic*

PACE, Vol. 23 November 2000, Part II 1965

Critical Value of Baroreflex Sensitivity Determined by Spectral Analysis in Risk Stratification After Myocardial Infarction

NATASA HONZIKOVA, BOHUMIL FISER, and BORIVOJ SEMRAD*

From the Department of Physiology, Faculty of Medicine, Masaryk University, and the *1st Department of Medicine, Faculty of Medicine, Masaryk University, Brno, Czech Republic

- zavedení stanovení BRS u ***hypertenzních*** pacientů (BRS nižší než 5 ms/mmHg)

- využití pro studium časných či pozdních změn účinků léčby kardiotoxicky a neurotoxicky působícími ***antracykliny*** u ***onkologicky*** nemocných

- předurčení rizika změn autonomního nervstva s dopadem na hladiny krevního tlaku u nemocných

s ***diabetes mellitus***


MINISTERSTVO ŠKOLSTVÍ, MLÁDEŽE A TĚLOVÝCHOVY
EVROPSKÁ UNIE
EVROPSKÝ FOND PRO REGIONÁLNÍ ROZVOJ
INVESTICE DO VAŠÍ BUDOUCNOSTI
OP Výzkum a vývoj pro inovace
Děkujeme za pozornost
NO
Fishing