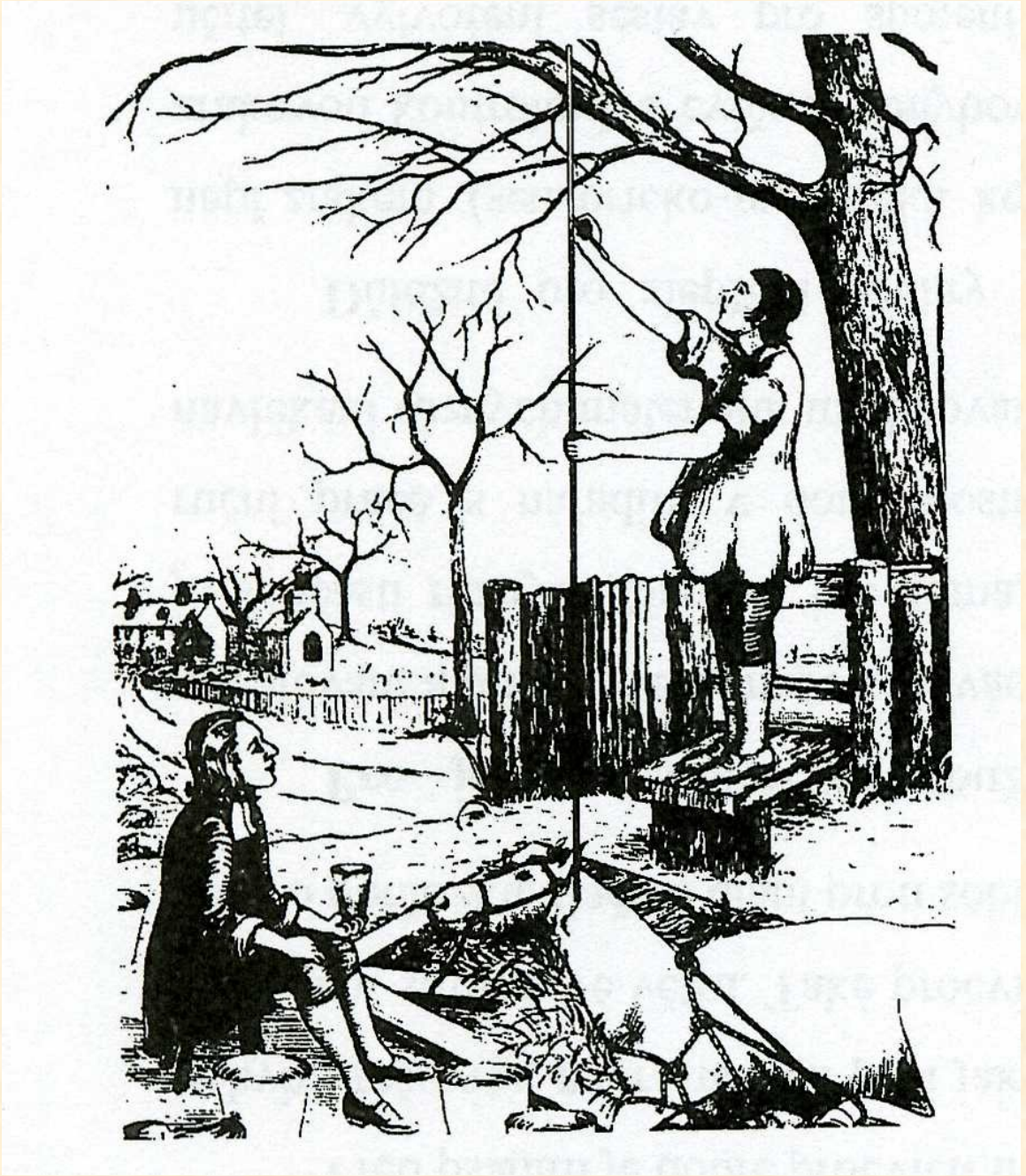


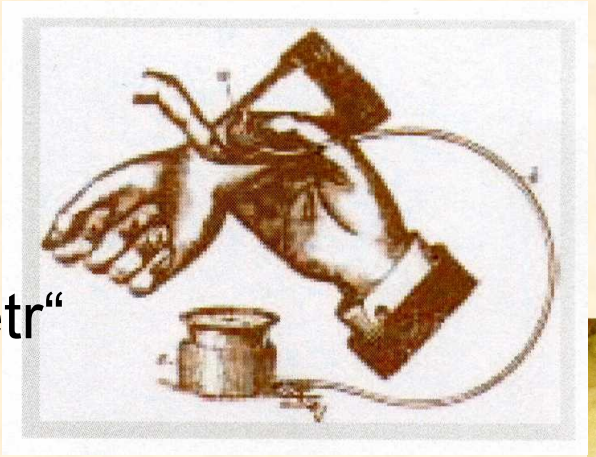
Blood pressure measurement

The system pressure values are, for technical reasons, dependent on:

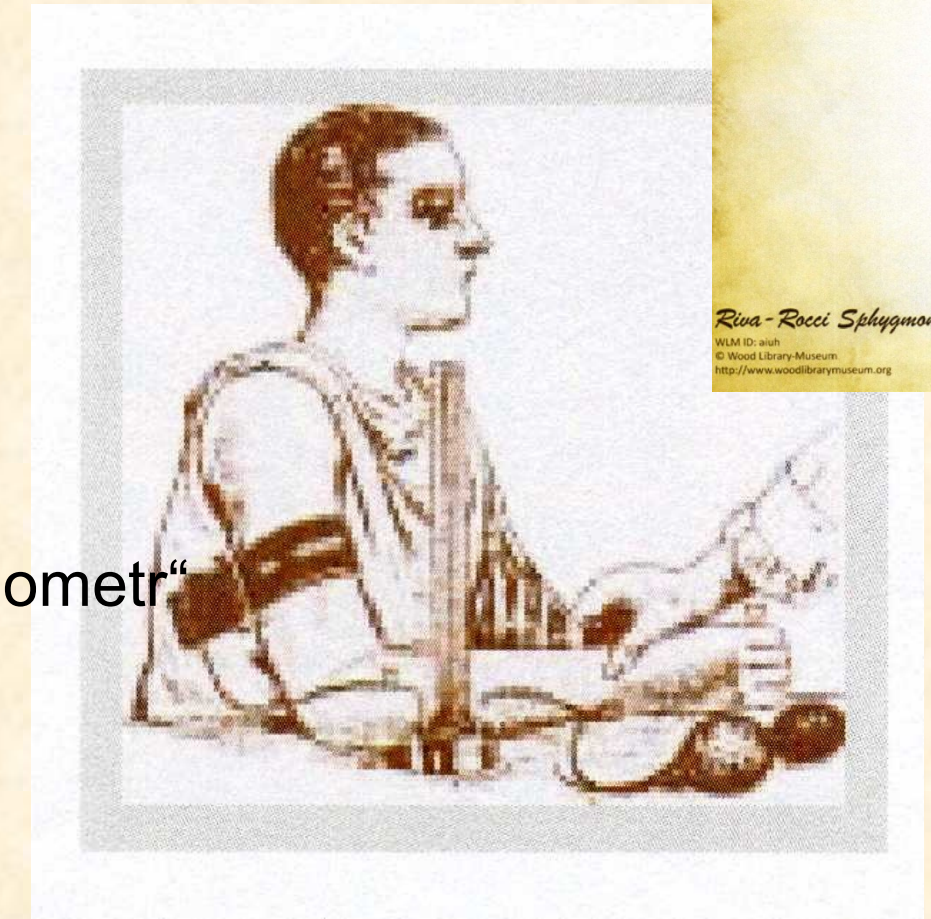
- Measuring method used
  - Non-invasive methods:
    - auscultatory
    - oscillometry
    - ultrasound
    - photopletysmography
  - Invasive methods
    - indirect – Swan-Ganz´s catheter
    - direct – catheter with a pressure sensor at the end
- Methodology
  - Clinical measurement – in ambulance - practitioner
  - Home measurement
  - 24hour ambulatory blood pressure monitoring

Palpatory method

Austrian Von Basch
„aneroid sfygmomanometr“
With baloon on wrist
1876



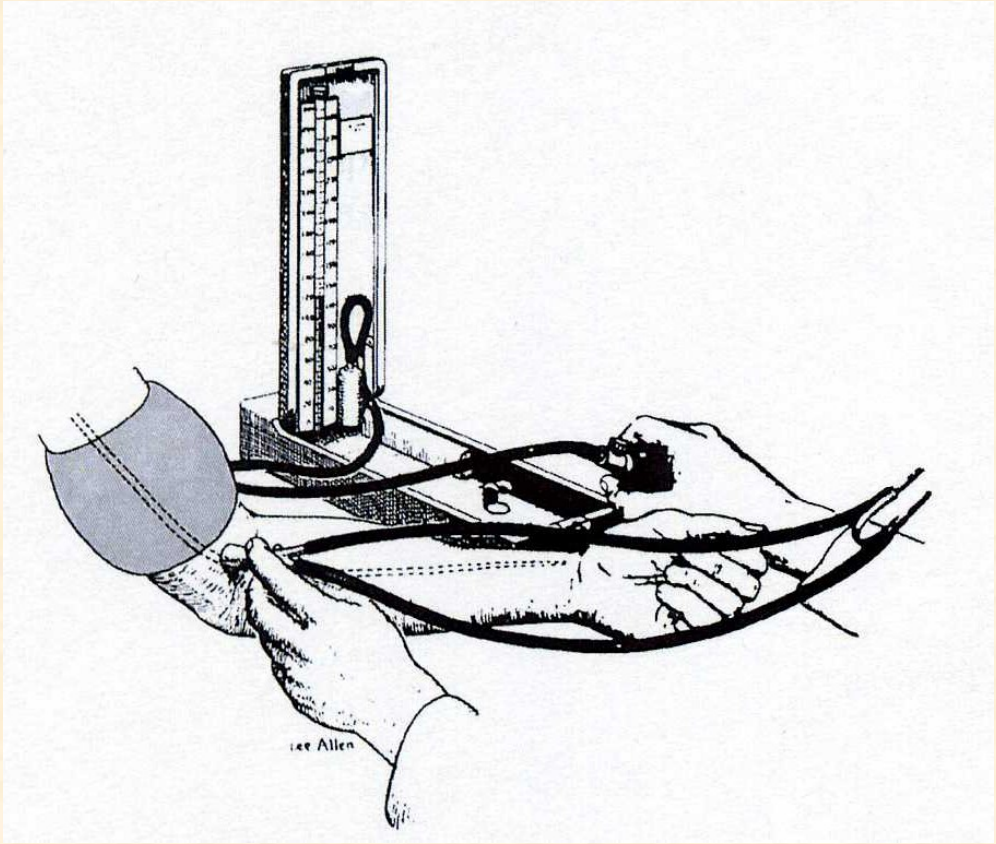
Italian physician
Riva Rocci
„mercury sfygmomanometr“
With cuff on the arm
1896



Auscultatory method

Russian army surgeon
Nikolaj Korotkoff
1904

„mercury sfygmomanometr“
The cuff on the arm,
stethoscope in the area of
the elbow



Auscultatory methods

- based on detection of Korotkoff phenomenons
- „gold standard“
- with comparison on intra-arterial measurement of blood pressure – we will find: lower values for SBP and higher values of DBP

  /this is only technical systemic mistake – does not matter/
- According a guidelines for diagnostic of arterial hypertension: we diagnose arterial hypertension: **repeated blood pressure increase above 140/90mmHg, demonstrated at least in two out of three measurements using the auscultation method in the clinical setting**

Oscillometric method

- Author: Mr. Marey – the first describe on 1876
- It has been repeatedly demonstrated that the oscillation of BP in the sphygmomanometric cuff is measured during its gradual discharge - **the point of maximum oscillation corresponds to the mean arterial pressure measured invasively**
- Oscillations begin approximately around systolic pressure values and continue after deflation of the cuff = **both systolic and diastolic pressure is estimated only indirectly based on empirical derived algorithms**
  - Advantage: Less susceptible to external noise
    Disadvantage: definitely unreliability in physical activity - distortion by motion artifacts + susceptible to low-frequency mechanical vibrations

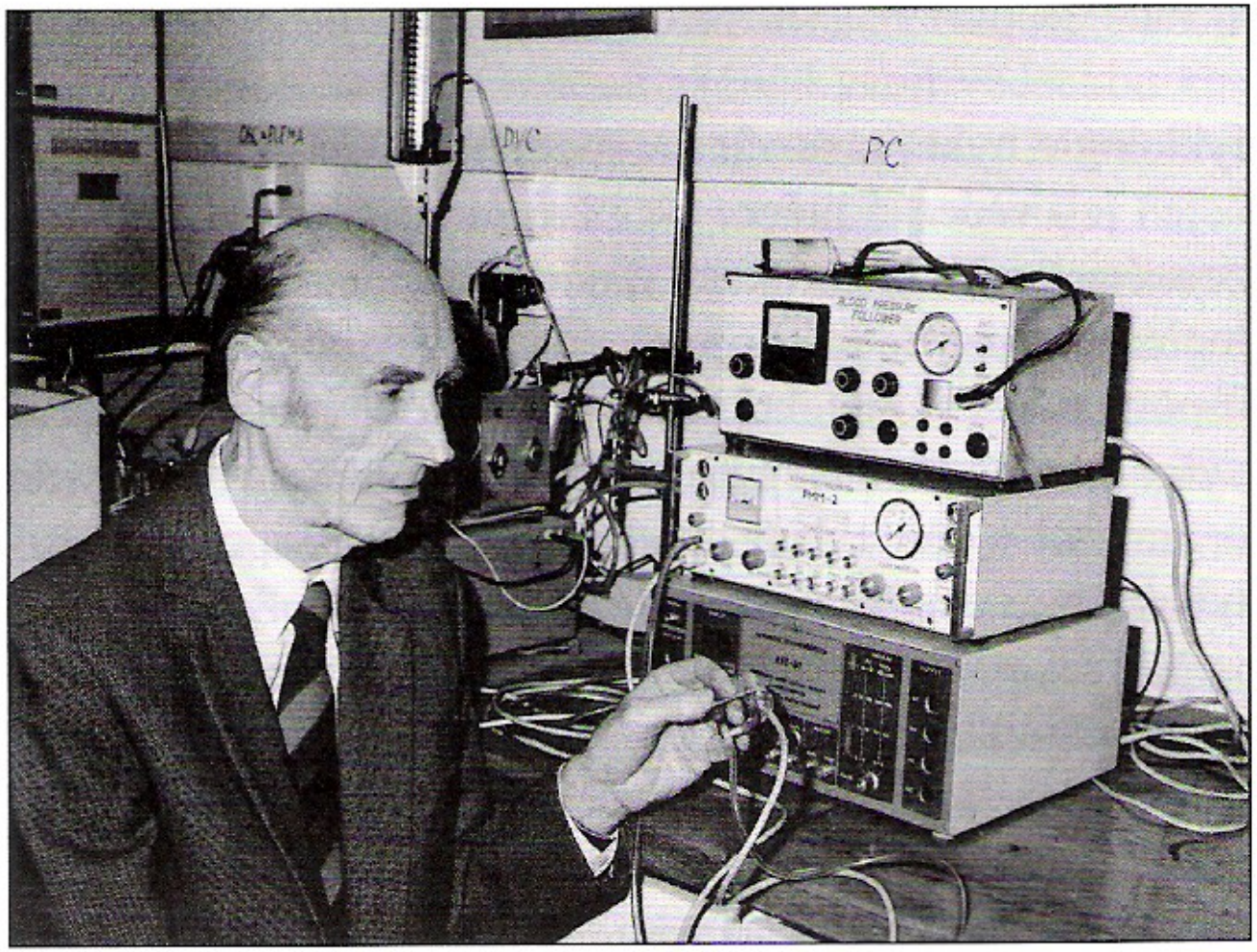
Ultrasound method

- The device includes an ultrasonic vibration generator and an ultrasonic sensor - placement via the brachial artery and under the sphygmomanometric cuff
  When deflate the cuff, it induces a systolic movement of the arterial wall that causes the Doppler phase shift in the transmitted ultrasound signal; diastolic BP is calculated by a significant reduction in arterial wall motions

- Other variant: systolic BP based on blood flow detection - in newborns and small children

Digital photoplethysmography

- Continuously blood pressure measurement - „beat to beat“ – from digital artery
- Profesor Jan Peňáz – Department of Physiology – Masaryk university in Brno - patent 1969
- Disadvantage: can not be used in conditions with peripheral vasoconstriction (shock states, vasoneurosis, diabetic angiopathy)

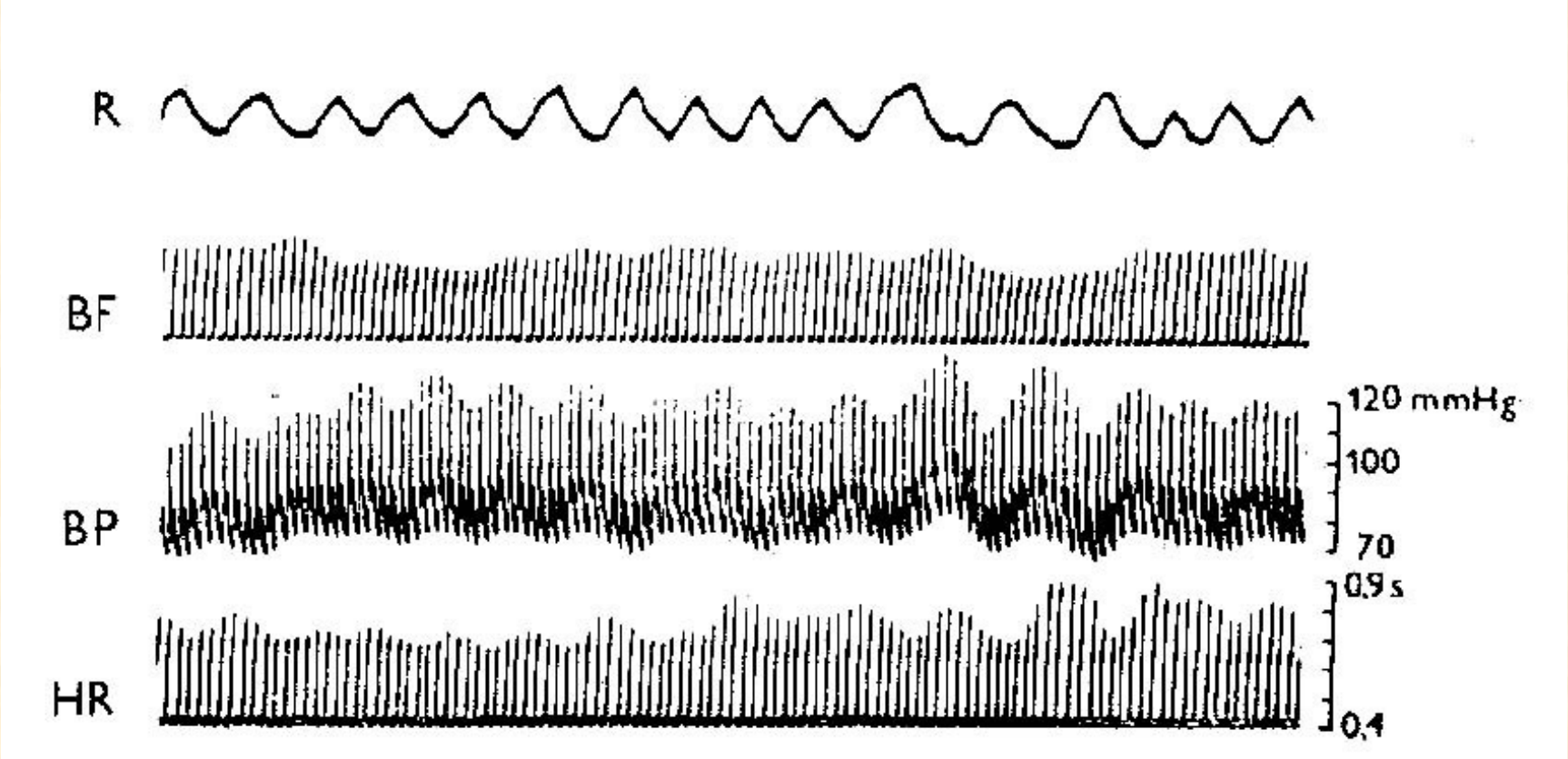

PC
BLOOD PRESSURE
FOLLOWER

- 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

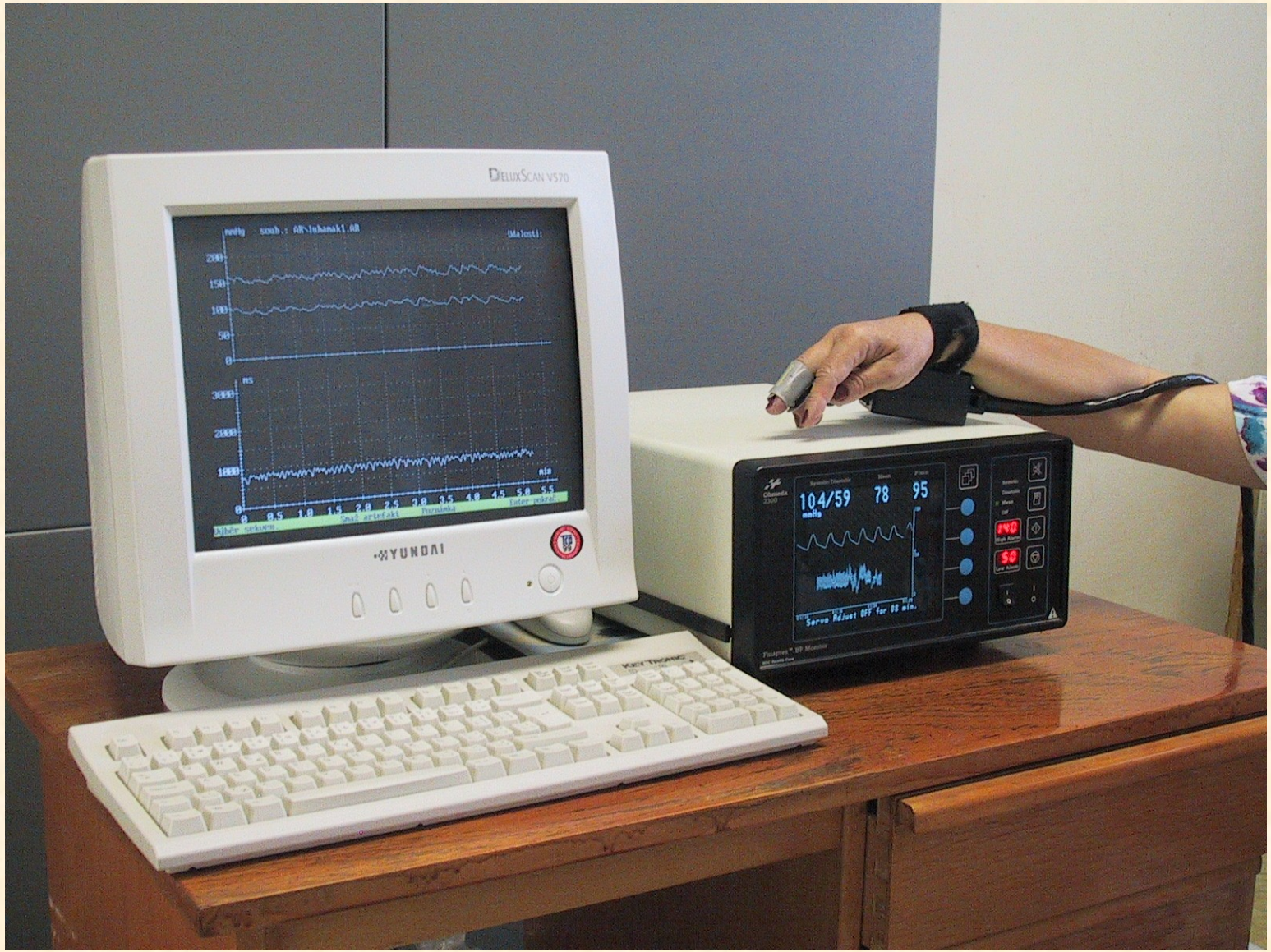
Penaz patent

- He used the signal from the photocell to control the external cuff pressure and that to keep the finger volume unchanged. This has achieved that pressure in the cuff monitors blood pressure in the artery.

Record of breathing and waves in circulatory parameters (Peňáz´s photoplethysmomanometr)



Finapres (Ohmeda, USA)




start / stop
FMS Finometer

Invasive measurement of blood pressure

- The most accurate measurement method of BP – BUT HIGH RISK:
  - difficult accessibility, risk of infection diseases
  Usage: BP monitoring in critical states (coronary units, intensive care units); in more complex therapeutic procedures
  - Indirect - Swan-Ganze catheter - hollow tube, on the vessel side with a hole, the other side connected to the sensor - filled with physiological solution - transfer of pressure changes from the vessel's light towards the sensor – inaccurate
  - Direct – special sensor – special microsensor on the vessel side - the blood pressure signal is transmitted from it
  - up-to-date catheters - signal transmission via fiber optics
  - **Important for the diagnosis of all forms of pulmonary hypertension**

Methodology

Clinical statement

- **In keeping with a good practice is still auscultation method able to report reliable results**

- We must rely on *white-coat hypertension* versus *masked hypertension* in some patients

  There is always higher BP in the case of BP measurement by physician and lower values measured by nurse or technician

Methodology 2

„Home“ blood presure measurement

- Advantage: measurement by patients, elimination of white-coat hypertension effect, measurement in long period
- Disadvantage: technical problem, correct measurement by patient
- Classic oscillometry method – cuff on the arm
  - Attention on location of measurement on the wrist - in the vertical position - pressure above 15-20 mmHg higher than on the arm, even when in the heart position the SBP is higher by 2-3mmHg than on the arm
  - Finger position cuff (non digital photoplethysmography) - Higher values of 4 mmHg than on the arm (another characteristic of the pulse curve in the finger artery)

Values at home measurements are always lower than in the clinical setting – Hypertension society recommendation: BP higher than 135/85mmHg - are increased !

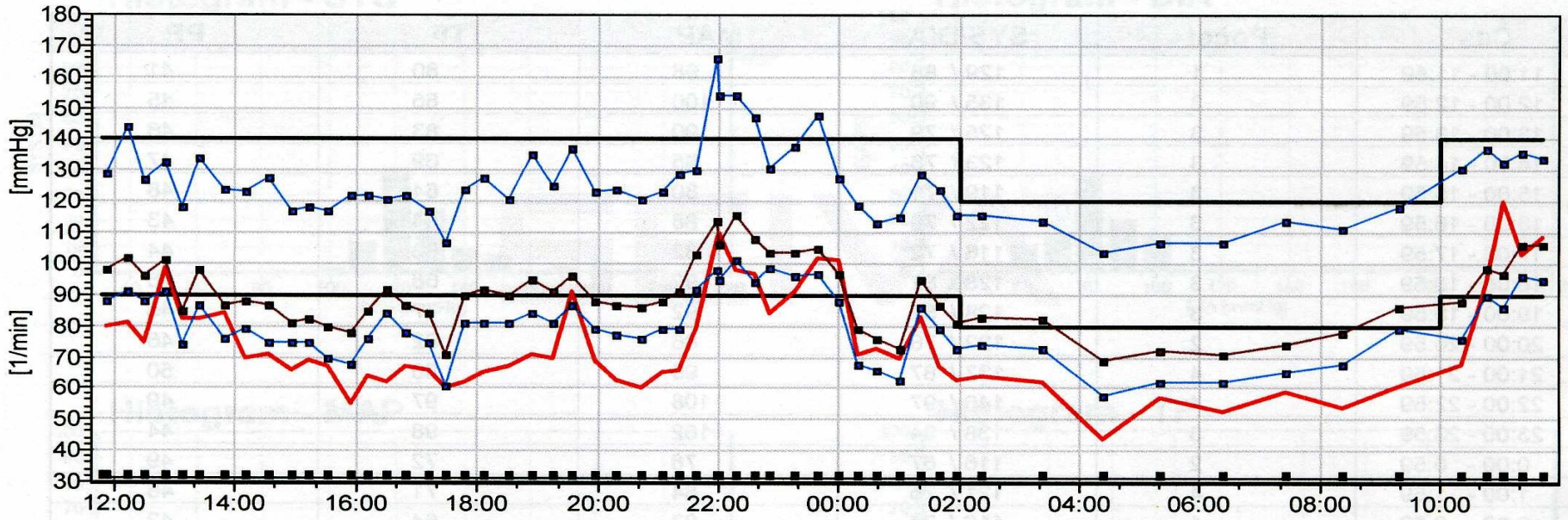
Methodology 3

24 hour ambulatory blood pressure monitoring

- Advantage: an overview of absolute values and variability in time-defined periods (! but still intermittent measurement!)
- Oscillometric method
- Information: SBP, DBP, pulse pressure, mean arterial pressure - profile of absolute values at monitored intervals; average and standard deviation for the period under review; % of the blood pressure parameters above the specified upper limit; calculation of different indexis; determination of variability of blood pressure fluctuation
- The number of BP increases in more than 40% of all values in either on night – or day-time interval – dg: arterial hypertension
- **ABPM values are lower than clinical values - recommendations:**

normal: below 135/85 daily and night under 120/70; 24 hour diameters 130/80 mmHg

Spojitý graf



Souhrnná statistika

Fáze	Celkem				Denní 10:00 - 2:00				Noční 2:00 - 10:00				Dopl.			
Doba	24h 0min				0h 0min				24h 0min				0h 0min			
Počet měření	59				0				59				0			
Uživatelská měření	2				0				2				0			
Chybná a vynechaná	2				0				2				0			
Překročení mezí	SYS >140: 11 % DIA > 90: 21 %				SYS >140: 0 % DIA > 90: 0 %				SYS >120: 68 % DIA > 80: 46 %				Noční pokles SYS=?% DIA=?%			
Statistika tlaků [mmHg]	min	avg	max	dev	min	avg	max	dev	min	avg	max	dev	min	avg	max	dev
SYS - systolický tlak	104	126	166	12	0	0	0	0	104	126	166	12	0	0	0	0
DIA - diastolický tlak	58	80	101	16	0	0	0	0	58	80	101	11	0	0	0	0
MAP - střední tlak	69	90	116	20	0	0	0	0	69	90	116	11	0	0	0	0
TF - tepová frekvence	44	75	120	26	0	0	0	0	44	75	120	17	0	0	0	0

Závěr vyšetření

OXFORD

AMBULATORY BLOOD PRESSURE REPORT

RESULTS PRINTOUT

Sample No	Time	Blood pressure Systolic/Diastolic mmHg	Mean mmHg	Heart rate bpm	Tag	Extra Reading	Error/ Comments
1	08:34	105/ 78	87	72	1	***	
2	08:40	95/ 75	81	70	1		
3	08:52	53/ 34	40	***	1		TC3/4,TC2,TC5/6
4	08:56	118/ 69	85	70	1		
5	09:04	113/ 76	88	67	1		
6	09:20	116/ 90	98	69	1		
7	09:38	116/ 74	88	66	1		TC5/6
8	09:52	111/ 78	89	68	1		TC5/6
9	10:11	146/103	117	66	1		1
10	10:15	130/ 86	100	63	1		
11	10:30	122/ 85	97	63	1		
12	10:48	120/ 77	91	65	1		
13	11:04	130/ 76	94	74	1		TC5/6
14	11:20	***/ 73	***	70	1		TC5/6,8
15	11:24	110/ 79	89	66	1		
16	11:35	134/ 95	108	68	1		1,TC5/6
17	11:39	125/ 85	98	62	1		
18	11:47	116/ 79	91	63	1		
19	11:58	***/ 83	***	73	1		TC5/6,8
20	12:02	118/ 73	88	70	1		TC5/6
21	12:16	105/ 72	83	62	1		
22	12:33	118/ 80	92	65	1		
23	12:45	100/ 68	78	69	1		
24	12:55	136/ 99	111	75	1		1,TC5/6
25	12:59	114/ 73	86	72	1		TC5/6
26	13:05	100/ 65	76	138	1		TC5/6
27	13:20	120/ 75	90	66	1		
28	13:39	101/ 70	80	70	1		
29	13:53	120/ 78	92	63	1		
30	14:03	137/ 83	101	71	1		
31	14:18	126/ 86	99	64	1		
32	14:34	126/ 83	97	64	1		
33	14:46	117/ 79	91	63	1		
34	15:01	120/ 83	95	64	1		
35	15:11	107/ 77	87	65	1		

Errors:
1. Systolic pressure greater than max cuff pressure setting
   Could not fully occlude arm
TC3/4. Absence/irregularity of k-sounds.
TC2. EKG trigger failure.
TC5/6. Pressure readings irregular- patient movement.
8. Systolic pressure not found.

Name: kucera martin,
Sex: male

Date of birth: 14.01.80

Measurement date: 29.05.00
Print-out date: 08.03.01

numeric display of day / night phase

	overall time 08:15 - 08:00		day phase 06:00 - 22:00		night phase 22:00 - 06:00		Day -> Night
	mean	max	mean	max	mean	max	
Ps [mmHg]	127	160	129	160	118	152	-8 %
Pd [mmHg]	74	120	76	120	63	81	-17 %
Pm [mmHg]	91	133	93	133	81	104	
BP-Ampl.	53	95	52	95	55	76	
Pulse [1/min]	71	103	74	103	62	79	-16 %
measurement count	95		76		19		
repeat measurements	13		10		3		
error + ignored meas.	14		11		3		
	count	%	count	%	count	%	
Ps > 140 mmHg:	14	17	12	18	2	13	
Pd > 90 mmHg:	9	11	9	14			
Pulse > 100 / min:	2	2	2	3			

Methodology 4

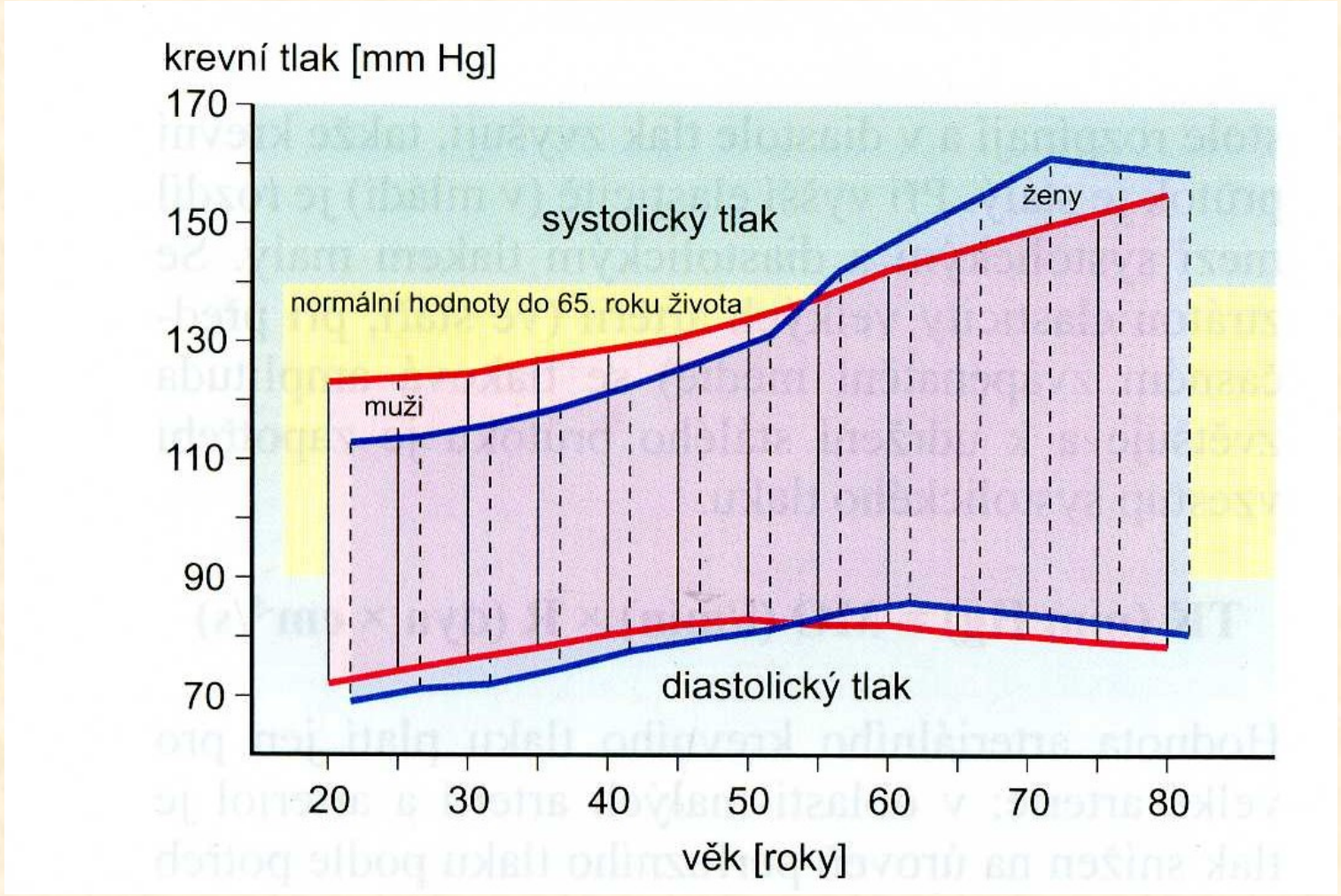
Continuously blood pressure measurement

- Beat to beat record by Penaz method
- BP is dynamic parameter
  - variability of fluctuation of heart rate and blood pressure – regulation by baroreflex – cooperation both parts of autonomic nervous system (symphathetic and parasymphathetic part)
  - Necessary component in clinical tests - head up table test (on inclined plane) and BP dysregulation in young subjects - dif.dg syncope
  - BP regulation research - maneuvers – Valsalva etc. ... ..
  - BP measurement in extreme situations: supersonic airplane pilots – overload condition, the cosmic program – weightlessness condition etc.

Blood pressure

in children

Age influence on blood pressure in man and female



Fölsch et al., Patologická fyziologie, Grada 2003

For children aged 1 to 13 years/aged ≥13 years

- **Normal BP:** <90th percentile // <120/ <80 mmHg
- **Elevated BP:** ≥ 90th percentile to <95th percentile//120/ <80 to 129/ <80 mmHg
  - or 120/80 mmHg to <95th percentile (whichever is lower)
- **Stage 1 HTN**: : ≥ 95th percentile to <95th percentile+12 mmHg//130/80 to 139/89 mmHg
  - Or 130/80 to 139/89 mmHg (whichever is lower)
- **Stage 2 HTN:** ≥ 95th percentile +12 mmHg// ≥140/90 mmHg
  - Or ≥140/90 mmHg (whichever is lower)

Flynn JT, Kaelber DC, Baker-Smith CM, Blowey D, Carroll AE, Daniels SR, et al., for the Subcommittee on Screening and Management of High Blood Pressure in Children. Clinical practice guideline for screening and management of high blood pressure in children and adolescents. **Pediatrics. 2017;140(3**):e20171904. https://doi.org/10.1542/peds.2017-1904.

B Girls

Age (y)	Blood Pressure Percentile	Systolic Blood Pressure (mmHg) Height Percentile or Measured Height							Diastolic Blood Pressure (mmHg) Height Percentile or Measured Height						
		5%	10%	25%	50%	75%	90%	95%	5%	10%	25%	50%	75%	90%	95%
1	Height (in)	29.7	30.2	30.9	31.8	32.7	33.4	33.9	29.7	30.2	30.9	31.8	32.7	33.4	33.9
	Height (cm)	75.4	76.6	78.6	80.8	83	84.9	86.1	75.4	76.6	78.6	80.8	83	84.9	86.1
	50th	84	85	86	86	87	88	88	41	42	42	43	44	45	46
	90th	98	99	99	100	101	102	102	54	55	56	56	57	58	58
	95th	101	102	102	103	104	105	105	59	59	60	60	61	62	62
	95th + 12 mmHg	113	114	114	115	116	117	117	71	71	72	72	73	74	74
2	Height (in)	33.4	34	34.9	35.9	36.9	37.8	38.4	33.4	34	34.9	35.9	36.9	37.8	38.4
	Height (cm)	84.9	86.3	88.6	91.1	93.7	96	97.4	84.9	86.3	88.6	91.1	93.7	96	97.4
	50th	87	87	88	89	90	91	91	45	46	47	48	49	50	51
	90th	101	101	102	103	104	105	106	58	58	59	60	61	62	62
	95th	104	105	106	106	107	108	109	62	63	63	64	65	66	66
	95th + 12 mmHg	116	117	118	118	119	120	121	74	75	75	76	77	78	78
3	Height (in)	35.8	36.4	37.3	38.4	39.6	40.6	41.2	35.8	36.4	37.3	38.4	39.6	40.6	41.2
	Height (cm)	91	92.4	94.9	97.6	100.5	103.1	104.6	91	92.4	94.9	97.6	100.5	103.1	104.6
	50th	88	89	89	90	91	92	93	48	48	49	50	51	53	53
	90th	102	103	104	104	105	106	107	60	61	61	62	63	64	65
	95th	106	106	107	108	109	110	110	64	65	65	66	67	68	69
	95th + 12 mmHg	118	118	119	120	121	122	122	76	77	77	78	79	80	81
4	Height (in)	38.3	38.9	39.9	41.1	42.4	43.5	44.2	38.3	38.9	39.9	41.1	42.4	43.5	44.2
	Height (cm)	97.2	98.8	101.4	104.5	107.6	110.5	112.2	97.2	98.8	101.4	104.5	107.6	110.5	112.2
	50th	89	90	91	92	93	94	94	50	51	51	53	54	55	55
	90th	103	104	105	106	107	108	108	62	63	64	65	66	67	67
	95th	107	108	109	109	110	111	112	66	67	68	69	70	70	71
	95th + 12 mmHg	119	120	121	121	122	123	124	78	79	80	81	82	82	83
5	Height (in)	40.8	41.5	42.6	43.9	45.2	46.5	47.3	40.8	41.5	42.6	43.9	45.2	46.5	47.3
	Height (cm)	103.6	105.3	108.2	111.5	114.9	118.1	120	103.6	105.3	108.2	111.5	114.9	118.1	120
	50th	90	91	92	93	94	95	96	52	52	53	55	56	57	57
	90th	104	105	106	107	108	109	110	64	65	66	67	68	69	70
	95th	108	109	109	110	111	112	113	68	69	70	71	72	73	73
	95th + 12 mmHg	120	121	121	122	123	124	125	80	81	82	83	84	85	85
6	Height (in)	43.3	44	45.2	46.6	48.1	49.4	50.3	43.3	44	45.2	46.6	48.1	49.4	50.3
	Height (cm)	110	111.8	114.9	118.4	122.1	125.6	127.7	110	111.8	114.9	118.4	122.1	125.6	127.7
	50th	92	92	93	94	96	97	97	54	54	55	56	57	58	59
	90th	105	106	107	108	109	110	111	67	67	68	69	70	71	71
	95th	109	109	110	111	112	113	114	70	71	72	72	73	74	74
	95th + 12 mmHg	121	121	122	123	124	125	126	82	83	84	84	85	86	86
7	Height (in)	45.6	46.4	47.7	49.2	50.7	52.1	53	45.6	46.4	47.7	49.2	50.7	52.1	53
	Height (cm)	115.9	117.8	121.1	124.9	128.8	132.5	134.7	115.9	117.8	121.1	124.9	128.8	132.5	134.7
	50th	92	93	94	95	97	98	99	55	55	56	57	58	59	60
	90th	106	106	107	109	110	111	112	68	68	69	70	71	72	72
	95th	109	110	111	112	113	114	115	72	72	73	73	74	74	75
	95th + 12 mmHg	121	122	123	124	125	126	127	84	84	85	85	86	86	87
8	Height (in)	47.6	48.4	49.8	51.4	53	54.5	55.5	47.6	48.4	49.8	51.4	53	54.5	55.5
	Height (cm)	121	123	126.5	130.6	134.7	138.5	140.9	121	123	126.5	130.6	134.7	138.5	140.9
	50th	93	94	95	97	98	99	100	56	56	57	59	60	61	61
	90th	107	107	108	110	111	112	113	69	70	71	72	72	73	73
	95th	110	111	112	113	115	116	117	72	73	74	74	75	75	75
	95th + 12 mmHg	122	123	124	125	127	128	129	84	85	86	86	87	87	87
9	Height (in)	49.3	50.2	51.7	53.4	55.1	56.7	57.7	49.3	50.2	51.7	53.4	55.1	56.7	57.7
	Height (cm)	125.3	127.6	131.3	135.6	140.1	144.1	146.6	125.3	127.6	131.3	135.6	140.1	144.1	146.6
	50th	95	95	97	98	99	100	101	57	58	59	60	60	61	61
	90th	108	108	109	111	112	113	114	71	71	72	73	73	73	73
	95th	112	112	113	114	116	117	118	74	74	75	75	75	75	75
	95th + 12 mmHg	124	124	125	126	128	129	130	86	86	87	87	87	87	87

Age (y)	Blood Pressure Percentile	Systolic Blood Pressure (mmHg) Height Percentile or Measured Height							Diastolic Blood Pressure (mmHg) Height Percentile or Measured Height						
		5%	10%	25%	50%	75%	90%	95%	5%	10%	25%	50%	75%	90%	95%
10	Height (in)	51.1	52	53.7	55.5	57.4	59.1	60.2	51.1	52	53.7	55.5	57.4	59.1	60.2
	Height (cm)	129.7	132.2	136.3	141	145.8	150.2	152.8	129.7	132.2	136.3	141	145.8	150.2	152.8
	50th	96	97	98	99	101	102	103	58	59	59	60	61	61	62
	90th	109	110	111	112	113	115	116	72	73	73	73	73	73	73
	95th	113	114	114	116	117	119	120	75	75	76	76	76	76	76
	95th + 12 mmHg	125	126	126	128	129	131	132	87	87	88	88	88	88	88
11	Height (in)	53.4	54.5	56.2	58.2	60.2	61.9	63	53.4	54.5	56.2	58.2	60.2	61.9	63
	Height (cm)	135.6	138.3	142.8	147.8	152.8	157.3	160	135.6	138.3	142.8	147.8	152.8	157.3	160
	50th	98	99	101	102	104	105	106	60	60	60	61	62	63	64
	90th	111	112	113	114	116	118	120	74	74	74	74	74	75	75
	95th	115	116	117	118	120	123	124	76	77	77	77	77	77	77
	95th + 12 mmHg	127	128	129	130	132	135	136	88	89	89	89	89	89	89
12	Height (in)	56.2	57.3	59	60.9	62.8	64.5	65.5	56.2	57.3	59	60.9	62.8	64.5	65.5
	Height (cm)	142.8	145.5	149.9	154.8	159.6	163.8	166.4	142.8	145.5	149.9	154.8	159.6	163.8	166.4
	50th	102	102	104	105	107	108	108	61	61	61	62	64	65	65
	90th	114	115	116	118	120	122	122	75	75	75	75	76	76	76
	95th	118	119	120	122	124	125	126	78	78	78	78	79	79	79
	95th + 12 mmHg	130	131	132	134	136	137	138	90	90	90	90	91	91	91
13	Height (in)	58.3	59.3	60.9	62.7	64.5	66.1	67	58.3	59.3	60.9	62.7	64.5	66.1	67
	Height (cm)	148.1	150.6	154.7	159.2	163.7	167.8	170.2	148.1	150.6	154.7	159.2	163.7	167.8	170.2
	50th	104	105	106	107	108	108	109	62	62	63	64	65	65	66
	90th	116	117	119	121	122	123	123	75	75	75	76	76	76	76
	95th	121	122	123	124	126	126	127	79	79	79	79	80	80	81
	95th + 12 mmHg	133	134	135	136	138	138	139	91	91	91	91	92	92	93
14	Height (in)	59.3	60.2	61.8	63.5	65.2	66.8	67.7	59.3	60.2	61.8	63.5	65.2	66.8	67.7
	Height (cm)	150.6	153	156.9	161.3	165.7	169.7	172.1	150.6	153	156.9	161.3	165.7	169.7	172.1
	50th	105	106	107	108	109	109	109	63	63	64	65	66	66	66
	90th	118	118	120	122	123	123	123	76	76	76	76	77	77	77
	95th	123	123	124	125	126	127	127	80	80	80	80	81	81	82
	95th + 12 mmHg	135	135	136	137	138	139	139	92	92	92	92	93	93	94
15	Height (in)	59.7	60.6	62.2	63.9	65.6	67.2	68.1	59.7	60.6	62.2	63.9	65.6	67.2	68.1
	Height (cm)	151.7	154	157.9	162.3	166.7	170.6	173	151.7	154	157.9	162.3	166.7	170.6	173
	50th	105	106	107	108	109	109	109	64	64	64	65	66	67	67
	90th	118	119	121	122	123	123	124	76	76	76	77	77	78	78
	95th	124	124	125	126	127	127	128	80	80	80	81	82	82	82
	95th + 12 mmHg	136	136	137	138	139	139	140	92	92	92	93	94	94	94
16	Height (in)	59.9	60.8	62.4	64.1	65.8	67.3	68.3	59.9	60.8	62.4	64.1	65.8	67.3	68.3
	Height (cm)	152.1	154.5	158.4	162.8	167.1	171.1	173.4	152.1	154.5	158.4	162.8	167.1	171.1	173.4
	50th	106	107	108	109	109	110	110	64	64	65	66	66	67	67
	90th	119	120	122	123	124	124	124	76	76	76	77	78	78	78
	95th	124	125	125	127	127	128	128	80	80	80	81	82	82	82
	95th + 12 mmHg	136	137	137	139	139	140	140	92	92	92	93	94	94	94
17	Height (in)	60.0	60.9	62.5	64.2	65.9	67.4	68.4	60.0	60.9	62.5	64.2	65.9	67.4	68.4
	Height (cm)	152.4	154.7	158.7	163.0	167.4	171.3	173.7	152.4	154.7	158.7	163.0	167.4	171.3	173.7
	50th	107	108	109	110	110	110	111	64	64	65	66	66	66	67
	90th	120	121	123	124	124	125	125	76	76	77	77	78	78	78
	95th	125	125	126	127	128	128	128	80	80	80	81	82	82	82
	95th + 12 mmHg	137	137	138	139	140	140	140	92	92	92	93	94	94	94

A Boys

Age (y)	Blood Pressure Percentile	Systolic Blood Pressure (mmHg) Height Percentile or Measured Height							Diastolic Blood Pressure (mmHg) Height Percentile or Measured Height						
		5%	10%	25%	50%	75%	90%	95%	5%	10%	25%	50%	75%	90%	95%
1	Height (in)	30.4	30.8	31.6	32.4	33.3	34.1	34.6	30.4	30.8	31.6	32.4	33.3	34.1	34.6
	Height (cm)	77.2	78.3	80.2	82.4	84.6	86.7	87.9	77.2	78.3	80.2	82.4	84.6	86.7	87.9
	50th	85	85	86	86	87	88	88	40	40	40	41	41	42	42
	90th	98	99	99	100	100	101	101	52	52	53	53	54	54	54
	95th	102	102	103	103	104	105	105	54	54	55	55	56	57	57
	95th + 12 mmHg	114	114	115	115	116	117	117	66	66	67	67	68	69	69
2	Height (in)	33.9	34.4	35.3	36.3	37.3	38.2	38.8	33.9	34.4	35.3	36.3	37.3	38.2	38.8
	Height (cm)	86.1	87.4	89.6	92.1	94.7	97.1	98.5	86.1	87.4	89.6	92.1	94.7	97.1	98.5
	50th	87	87	88	89	89	90	91	43	43	44	44	45	46	46
	90th	100	100	101	102	103	103	104	55	55	56	56	57	58	58
	95th	104	105	105	106	107	107	108	57	58	58	59	60	61	61
	95th + 12 mmHg	116	117	117	118	119	119	120	69	70	70	71	72	73	73
3	Height (in)	36.4	37	37.9	39	40.1	41.1	41.7	36.4	37	37.9	39	40.1	41.1	41.7
	Height (cm)	92.5	93.9	96.3	99	101.8	104.3	105.8	92.5	93.9	96.3	99	101.8	104.3	105.8
	50th	88	89	89	90	91	92	92	45	46	46	47	48	49	49
	90th	101	102	102	103	104	105	105	58	58	59	59	60	61	61
	95th	106	106	107	107	108	109	109	60	61	61	62	63	64	64
	95th + 12 mmHg	118	118	119	119	120	121	121	72	73	73	74	75	76	76
4	Height (in)	38.8	39.4	40.5	41.7	42.9	43.9	44.5	38.8	39.4	40.5	41.7	42.9	43.9	44.5
	Height (cm)	98.5	100.2	102.9	105.9	108.9	111.5	113.2	98.5	100.2	102.9	105.9	108.9	111.5	113.2
	50th	90	90	91	92	93	94	94	48	49	49	50	51	52	52
	90th	102	103	104	105	105	106	107	60	61	62	62	63	64	64
	95th	107	107	108	108	109	110	110	63	64	65	66	67	67	68
	95th + 12 mmHg	119	119	120	120	121	122	122	75	76	77	78	79	79	80
5	Height (in)	41.1	41.8	43.0	44.3	45.5	46.7	47.4	41.1	41.8	43.0	44.3	45.5	46.7	47.4
	Height (cm)	104.4	106.2	109.1	112.4	115.7	118.6	120.3	104.4	106.2	109.1	112.4	115.7	118.6	120.3
	50th	91	92	93	94	95	96	96	51	51	52	53	54	55	55
	90th	103	104	105	106	107	108	108	63	64	65	65	66	67	67
	95th	107	108	109	109	110	111	112	66	67	68	69	70	70	71
	95th + 12 mmHg	119	120	121	121	122	123	124	78	79	80	81	82	82	83
6	Height (in)	43.4	44.2	45.4	46.8	48.2	49.4	50.2	43.4	44.2	45.4	46.8	48.2	49.4	50.2
	Height (cm)	110.3	112.2	115.3	118.9	122.4	125.6	127.5	110.3	112.2	115.3	118.9	122.4	125.6	127.5
	50th	93	93	94	95	96	97	98	54	54	55	56	57	57	58
	90th	105	105	106	107	109	110	110	66	66	67	68	68	69	69
	95th	108	109	110	111	112	113	114	69	70	70	71	72	72	73
	95th + 12 mmHg	120	121	122	123	124	125	126	81	82	82	83	84	84	85
7	Height (in)	45.7	46.5	47.8	49.3	50.8	52.1	52.9	45.7	46.5	47.8	49.3	50.8	52.1	52.9
	Height (cm)	116.1	118	121.4	125.1	128.9	132.4	134.5	116.1	118	121.4	125.1	128.9	132.4	134.5
	50th	94	94	95	97	98	98	99	56	56	57	58	58	59	59
	90th	106	107	108	109	110	111	111	68	68	69	70	70	71	71
	95th	110	110	111	112	114	115	116	71	71	72	73	73	74	74
	95th + 12 mmHg	122	122	123	124	126	127	128	83	83	84	85	85	86	86
8	Height (in)	47.8	48.6	50	51.6	53.2	54.6	55.5	47.8	48.6	50	51.6	53.2	54.6	55.5
	Height (cm)	121.4	123.5	127	131	135.1	138.8	141	121.4	123.5	127	131	135.1	138.8	141
	50th	95	96	97	98	99	99	100	57	57	58	59	59	60	60
	90th	107	108	109	110	111	112	112	69	70	70	71	72	72	73
	95th	111	112	112	114	115	116	117	72	73	73	74	75	75	75
	95th + 12 mmHg	123	124	124	126	127	128	129	84	85	85	86	87	87	87
9	Height (in)	49.6	50.5	52	53.7	55.4	56.9	57.9	49.6	50.5	52	53.7	55.4	56.9	57.9
	Height (cm)	126	128.3	132.1	136.3	140.7	144.7	147.1	126	128.3	132.1	136.3	140.7	144.7	147.1
	50th	96	97	98	99	100	101	101	57	58	59	60	61	62	62
	90th	107	108	109	110	112	113	114	70	71	72	73	74	74	74
	95th	112	112	113	115	116	118	119	74	74	75	76	76	77	77
	95th + 12 mmHg	124	124	125	127	128	130	131	86	86	87	88	88	89	89

Age (y)	Blood Pressure Percentile	Systolic Blood Pressure (mmHg) Height Percentile or Measured Height							Diastolic Blood Pressure (mmHg) Height Percentile or Measured Height						
		5%	10%	25%	50%	75%	90%	95%	5%	10%	25%	50%	75%	90%	95%
10	Height (in)	51.3	52.2	53.8	55.6	57.4	59.1	60.1	51.3	52.2	53.8	55.6	57.4	59.1	60.1
	Height (cm)	130.2	132.7	136.7	141.3	145.9	150.1	152.7	130.2	132.7	136.7	141.3	145.9	150.1	152.7
	50th	97	98	99	100	101	102	103	59	60	61	62	63	63	64
	90th	108	109	111	112	113	115	116	72	73	74	74	75	75	76
	95th	112	113	114	116	118	120	121	76	76	77	77	78	78	78
	95th + 12 mmHg	124	125	126	128	130	132	133	88	88	89	89	90	90	90
11	Height (in)	53	54	55.7	57.6	59.6	61.3	62.4	53	54	55.7	57.6	59.6	61.3	62.4
	Height (cm)	134.7	137.3	141.5	146.4	151.3	155.8	158.6	134.7	137.3	141.5	146.4	151.3	155.8	158.6
	50th	99	99	101	102	103	104	106	61	61	62	63	63	63	63
	90th	110	111	112	114	116	117	118	74	74	75	75	75	76	76
	95th	114	114	116	118	120	123	124	77	78	78	78	78	78	78
	95th + 12 mmHg	126	126	128	130	132	135	136	89	90	90	90	90	90	90
12	Height (in)	55.2	56.3	58.1	60.1	62.2	64	65.2	55.2	56.3	58.1	60.1	62.2	64	65.2
	Height (cm)	140.3	143	147.5	152.7	157.9	162.6	165.5	140.3	143	147.5	152.7	157.9	162.6	165.5
	50th	101	101	102	104	106	108	109	61	62	62	62	62	63	63
	90th	113	114	115	117	119	121	122	75	75	75	75	75	76	76
	95th	116	117	118	121	124	126	128	78	78	78	78	78	79	79
	95th + 12 mmHg	128	129	130	133	136	138	140	90	90	90	90	90	91	91
13	Height (in)	57.9	59.1	61	63.1	65.2	67.1	68.3	57.9	59.1	61	63.1	65.2	67.1	68.3
	Height (cm)	147	150	154.9	160.3	165.7	170.5	173.4	147	150	154.9	160.3	165.7	170.5	173.4
	50th	103	104	105	108	110	111	112	61	60	61	62	63	64	65
	90th	115	116	118	121	124	126	126	74	74	74	75	76	77	77
	95th	119	120	122	125	128	130	131	78	78	78	78	80	81	81
	95th + 12 mmHg	131	132	134	137	140	142	143	90	90	90	90	92	93	93
14	Height (in)	60.6	61.8	63.8	65.9	68.0	69.8	70.9	60.6	61.8	63.8	65.9	68.0	69.8	70.9
	Height (cm)	153.8	156.9	162	167.5	172.7	177.4	180.1	153.8	156.9	162	167.5	172.7	177.4	180.1
	50th	105	106	109	111	112	113	113	60	60	62	64	65	66	67
	90th	119	120	123	126	127	128	129	74	74	75	77	78	79	80
	95th	123	125	127	130	132	133	134	77	78	79	81	82	83	84
	95th + 12 mmHg	135	137	139	142	144	145	146	89	90	91	93	94	95	96
15	Height (in)	62.6	63.8	65.7	67.8	69.8	71.5	72.5	62.6	63.8	65.7	67.8	69.8	71.5	72.5
	Height (cm)	159	162	166.9	172.2	177.2	181.6	184.2	159	162	166.9	172.2	177.2	181.6	184.2
	50th	108	110	112	113	114	114	114	61	62	64	65	66	67	68
	90th	123	124	126	128	129	130	130	75	76	78	79	80	81	81
	95th	127	129	131	132	134	135	135	78	79	81	83	84	85	85
	95th + 12 mmHg	139	141	143	144	146	147	147	90	91	93	95	96	97	97
16	Height (in)	63.8	64.9	66.8	68.8	70.7	72.4	73.4	63.8	64.9	66.8	68.8	70.7	72.4	73.4
	Height (cm)	162.1	165	169.6	174.6	179.5	183.8	186.4	162.1	165	169.6	174.6	179.5	183.8	186.4
	50th	111	112	114	115	115	116	116	63	64	66	67	68	69	69
	90th	126	127	128	129	131	131	132	77	78	79	80	81	82	82
	95th	130	131	133	134	135	136	137	80	81	83	84	85	86	86
	95th + 12 mmHg	142	143	145	146	147	148	149	92	93	95	96	97	98	98
17	Height (in)	64.5	65.5	67.3	69.2	71.1	72.8	73.8	64.5	65.5	67.3	69.2	71.1	72.8	73.8
	Height (cm)	163.8	166.5	170.9	175.8	180.7	184.9	187.5	163.8	166.5	170.9	175.8	180.7	184.9	187.5
	50th	114	115	116	117	117	118	118	65	66	67	68	69	70	70
	90th	128	129	130	131	132	133	134	78	79	80	81	82	82	83
	95th	132	133	134	135	137	138	138	81	82	84	85	86	86	87
	95th + 12 mmHg	144	145	146	147	149	150	150	93	94	96	97	98	98	99

Blood pressure

- Immediately after birth – high blood pressure:
  - Stress after delivery, increase concentration of catecholamine and cortizol
- After 1st day …….. 70/50 mmHg:
  - Open of pulmonary and intestine circulation
- During pubertas:
  - Development of regulatory mechanism
  - Stimulation of external world

• Newborn	**80/46 mmHg**	10.6/6.1 kPa
• 3 years	**100/67**	13.3/8.9
• 10-11 years	**111/58**	14.8/7.7
• 13-14 years	**118/60**	15.7/8.0

Blood presure measurement in newborn and children

- Korotkoff method – for children over 1 year – use a correct size of cuff
- In the newborns, auscultation phenomena are poorly audible - there may be an underestimation of SBP
- better use the ultrasound method of the blood flow detector

The size of cuff

Body weight	age	size of cuff
1 500 g	newborn	2.5 cm
5 kg	3 month	4.5 cm
10 kg	15 month	6 cm
30 kg	9 year	7.5 cm
more than 30 kg	10 and more years	12 cm

Specific features measurement

Pregnant women

- Physiological profile of pregnancy - decrease of BP with increase in cardiac output and large decrease of peripheral resistance = special hyperkinetic conditions - Korotkoff phenomena we auscultated even after deflation of the cuff - diastolic BP we estimated in IV phase of Korotkoff phenomena

Elderly people with atherosclerosis - poor compressibility of the artery wall by a compression cuff - we need to inflate more - so we measure falsely higher SBP values - **pseudohypertension**

Obese persons – using the right size of the cuff !!!!! using a standard cuff – overstocking of SBP

Dynamic physical exercise - auscultation method may underestimate SBP by 15 mmHg, during recovery phase - overstatement of up to 30mmHg SBP; DBP less frequently but falsely low - better use for DBP measurement reading from phase IV of Korotkoff sounds

Actual blood pressure values are dependent on:

- factors that are conditioned by the organism
- on the measurement method
- in which conditions the measurements are performed (methodology)
- even on accuracy and reliability of instruments (technical page - necessary tests and calibration of pressure device / 1 year)
- **THIS MUST BE ALLOWED TO CONSIDER AT THE MEASUREMENT IN CLINICAL PRACTICE**

THANK YOU FOR YOUR ATTENTION