به‌نام خدای بخشاینده مهربان

In the name of Allah, the Beneficent, the Merciful.

Blood Presure Measurment

M.R.Abbasi
Nephrologist
NRC
TUMS
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Blood Pressure measurement

"The measurement of blood pressure is the clinical procedure of greatest importance that is performed in the sloppiest manner."

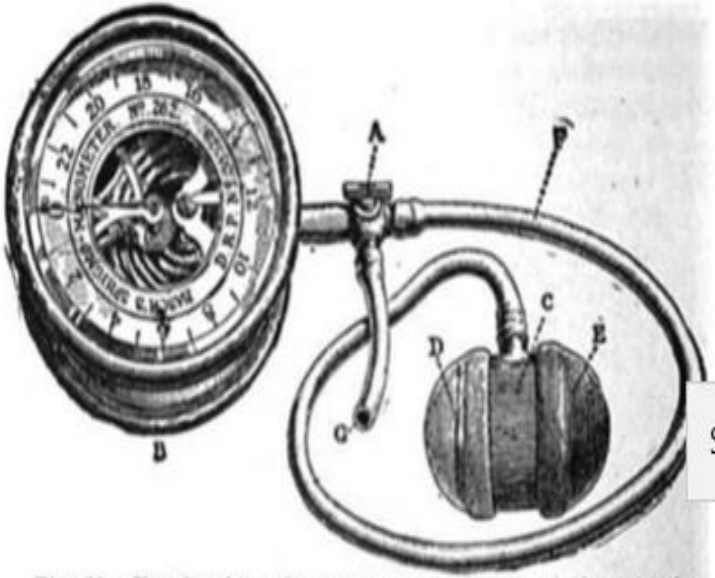
Kaplan N. M. Amer J Hypertension 1998: 11: 134-6

High blood pressure (BP) is the single leading risk factor for cardiovascular disease worldwide.

Cheung, Alfred K., et al. "International Consensus on Standardized Clinic Blood Pressure Measurement–A Call to Action." The American Journal of Medicine (2023).

The first measurement of BP

- 1733 - Reverend Stephen Hales first to measure BP
- Measured the height of a column of blood after cannulating the carotid artery in a horse with a brass pipe.
- The brass pipe was attached to a 12 inch glass tube(1733)
- Tube was connected to the pipe via a trachea of a goose



Save as

Fig. 29.—Von Basch's sphygmomanometer, from a specimen in the possession of the author. A is a three-way stopcock, by which the aneroid B can be put in communication either with the bulb C or with the outer air. C is a metal ring with caps of india rubber D and E. F is the India rubber tube connecting the bulb and aneroid. This is not the first form of von Basch's sphygmomanometer. The bulb which he first used was included in a metal case somewhat resembling Marey's cardiograph. My instrument needed repair, so I sent it to Vienna, and it was returned by the maker with the bulb figured above.

a pressure bag on the other. After the ring has been placed on the finger the blood is squeezed up from the tip by pressing upward over it a small strong rubber ring or by winding over it a piece of elastic tube, which renders the end of

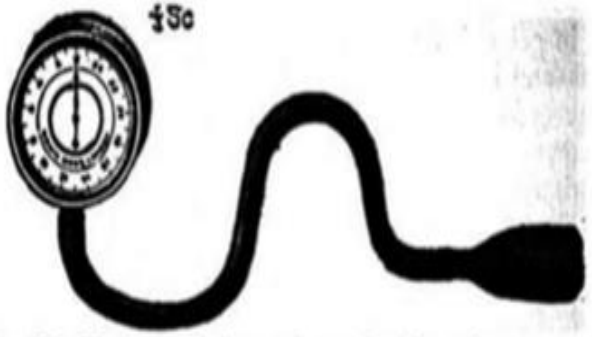


Fig. 30.—Most recent form of von Basch's sphygmomanometer. (Messrs. Down Bros., 21 St. Thomas's street, S. E.)

Fig. 2 Development of a convenient and simple way of measuring blood pressure by von Basch (1876), an Austrian physician (http://www4.ncsu.edu/~msolufse/bpmeasurement.pdf)

Eureka!

- In late 1890s, an Italian physician – Scipione Riva Rocci invented the Sphygmomanometer

Shygmo (from the Greek) => pulse

Manometer => pressure meter

- Consisted of a mercury column Manometer, a rubber sleeve which is filled with air, and a squeeze bag to inflate the rubber sleeve

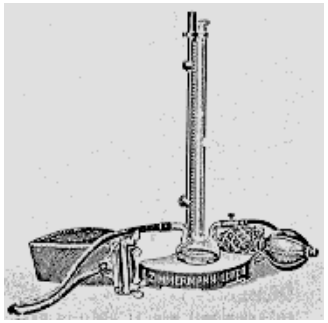


Fig. 5 Conventional mercury sphygmomanometer with an arm cuff developed by Riva-Rocci (1896) (http://www4.ncsu.edu/~msolufse/bpmeasurement.pdf)

Nowadays BP monitors

Table 1 Organizations Providing Online Lists of Validated BP Monitors

Organization	Monitor lists (language)	Scientific association	Website
STRIDE BP	International (English, Chinese, Spanish)	European Society of Hypertension - International Society of Hypertension - World Hypertension League	www.stridebp.org
BIHS	UK, Ireland (English)	British and Irish Hypertension Society	www.bihsoc.org/bp-monitors
VDL	US (English)	American Medical Association	www.validatebp.org
Hypertension Canada	Canada (English)	Hypertension Canada	www.hypertension.ca/bpdevices
Deutsche Hochdruckliga	Germany (German)	German High Pressure League	www.hochdruckliga.de/betroffene/blutdruckmessgeraete-mit-pruefsiegel
JSH	Japan (Japanese)	Japanese Society of Hypertension	www.jpnsh.jp/com_ac_wg1.html

BP = blood pressure; STRIDE BP = Science and Technology for Regional Innovation and Development in Europe Blood Pressure; VDL = validated device listing.

Two websites are not associated with a scientific organization (www.dableducational.org, www.medaval.ie). Modified from 2021 ESH practice guidelines for blood pressure measurement.[17]

Which machine?

- Every practice/ward should be using a validated manometer
- All manometers should be recalibrated and serviced annually
- Aneroid machines (not recommended) should be serviced more often as they deteriorate rapidly
- Useful website:- www.bhsoc.org

Manufacturer	Model	Price	Protocol
A C Cossor & Son	Greenlight 300	£136	International Protocol
A&D	TM-2430	£1,359	BHS A/A
A&D	TM-2655	£1,999	BHS A/A
A&D	TM-2656	Unknown	BHS A/A
Andon	KD-391	Unknown	International Protocol
Artsana	CS 410	Unknown	International Protocol
Artsana	CS 610	Unknown	International Protocol
BP Lab	BPLab 24-hour	£1,210	International Protocol, BHS A/A
BpTRU	BPM-100	£495	BHS A/A
BpTRU	BPM-200 *(D)	£575	BHS A/A
BpTRU	BPM-300 *(D)	£750	BHS A/A
BTL	BTL-08 ABPM II	Unknown	BHS B/B
Dinamap	Procare 100	£1,460	International Protocol
Dinamap	Procare 220	£1,704	International Protocol
Dinamap	Procare 230	£2,056	International Protocol
Dinamap	Procare 420	£2,173	International Protocol
EnvitecC-Wismar	PhysioQuant	Unknown	International Protocol
Ergoline	Ergoscan *(D)	Unknown	International Protocol
ET Medical Devices	Cardioline Walk200B *(D)	Unknown	BHS A/A, International Protocol
GE	Carescape V100	£1,200	International Protocol
GE Healthcare	Tonoport V	Unknown	International Protocol
HealthWorks	SCLV-2007 Cardio-Vascular Lab *(D)	£495	International Protocol
HeathSTATS International	Bpro	£1,950	International Protocol
Heine Gamma	G7 (G5)	Unknown	
Heine Gamma	XXL-LF	Unknown	International Protocol

BP Monitors
BHS Validation Service for Manufacturers
Process for Listing BP Monitors

Latest Guidelines
BP Monitors
Calendar of Events
FAQ
UK Professionals only
BHS Statements

Members Area

Blood Pressure Monitors Validated for Clinical Use

The table below give a comprehensive list of all the Validated Blood Pressure monitors that are suitable for use in the clinic. They are not necessarily suitable for use in the home.

You can search for a specific manufacturer, device or type by using the drop-down boxes at the top of the list. Additional information on each device can be accessed by clicking anywhere on the individual model.

Only the devices showing the BHS logo in the right hand column have been tested by the BHS Validation Service. All other devices have been tested independently.

The list is organised alphabetically in ascending order of price. Those devices where a price is not known are listed alphabetically at the end.

See also: BP Monitors For Home Use

If the table below is not loading, please click here to download a summary of the Clincial Use BP Monitors. If you have any further queries please contact: bhs@le.ac.uk

Select the type of monitor:

All Types

	Manufacturer	Model	Price	Protocol	BHS Validated

For Home Use

VIEW

For Specialist Use

VIEW

Not Recommended

VIEW


120
80
65
ADULT


3cm
22 – 32cm
A&D
SYSTOLIC
DIASTOLIC
PRESSURE
START
PUL. / min


ART

Manometers – electronic advantages

- You can effortlessly take several readings
- Mean while you can check pt records
- Some ‘whitecoat’ effect can be detected
- You can rely on the readings of other health care professionals.

(These advantages partly outweigh the disadvantage of the possible, slight inaccuracy of some devices).

BP measurement

- Three or more readings, separated by 1 minute
- Discard first reading and average last two
- If large difference take further readings.

BP measurement -cuffs

- Cuff too small or too big
- Normal cuff too small for 15% of patients
- Cuff not level with the heart
- Leaky rubber tubing or bladder*
- Faulty inflation/deflation device*

* Applies to mercury manometers only.

Cuff sizes

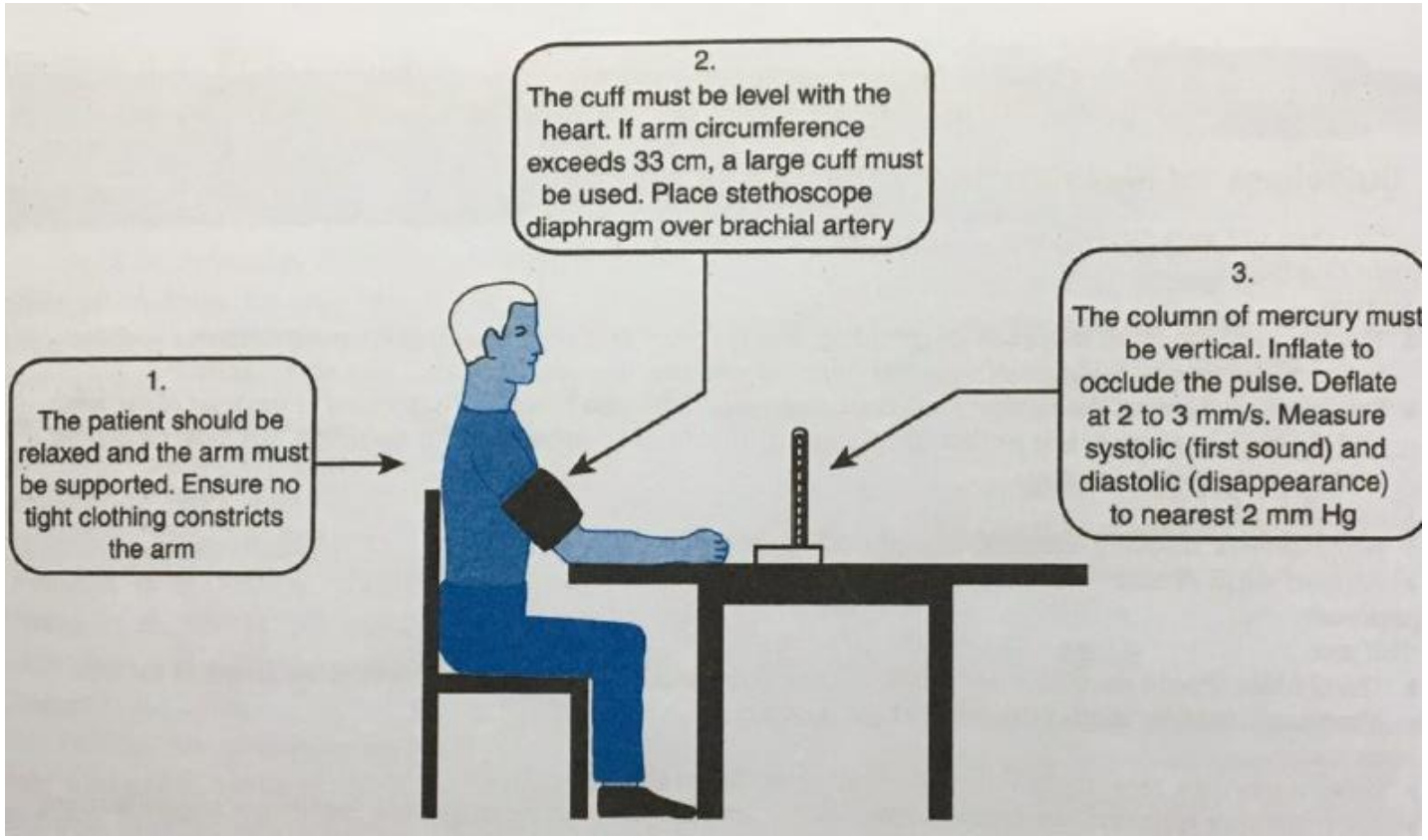
Type	Size	Suitability
Adult	12cm by 23cm	for smaller arms
Alternative cuff	12cm by 36cm	will cover 95% arms
Large adult	15cm by 36cm	Often too wide for ‘fat’ arms

Which arm?

- 6% of hypertensives can have as much as a 10 mmHg difference between arms
- If BP higher in one arm than the other, this arm must be used from then on
- Document this in records so that everyone uses the same arm.

Technique

- Patient seated and relaxed, not talking, legs uncrossed
- Tight arm clothing removed
- Correct cuff size
- Arm supported with cuff horizontal with heart
- Inform patient of discomfort and that several measurements will be taken
- Mercury manometer on firm and level surface at eye level
- Locate brachial or radial pulse.


2.
The cuff must be level with the heart. If arm circumference exceeds 33 cm, a large cuff must be used. Place stethoscope diaphragm over brachial artery
3.
The column of mercury must be vertical. Inflate to occlude the pulse. Deflate at 2 to 3 mm/s. Measure systolic (first sound) and diastolic (disappearance) to nearest 2 mm Hg
1.
The patient should be relaxed and the arm must be supported. Ensure no tight clothing constricts the arm

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THE AMERICAN JOURNAL of MEDICINE®

International Consensus on Standardized Clinic Blood Pressure Measurement — A Call to Action

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An automated upper-arm cuff monitor is strongly recommended

Cheung, Alfred K., et al. "International Consensus on Standardized Clinic Blood Pressure Measurement–A Call to Action." The American Journal of Medicine (2023).

Step 1 **Facility and equipment**	• Quiet room with a comfortable temperature. • Clinically validated BP measurement device; an automated device measuring BP at the brachial artery is recommended. • A range of cuff sizes to fit a range of upper-arm circumferences.
Step 2 **Personnel performing BP measurement**	• Trained healthcare professional should perform the BP measurement. Annual re-training is recommended.
Step 3 **Prepare the patient**	• The patient should be provided with instructions to abstain from caffeine, alcohol, nicotine, and exercise for at least 30 minutes prior to the BP measurement. • Eliminate discomfort such as a full bladder. • Prior to the BP measurement, there should be a short rest period (3–5 minutes) without provocation (including talking, or being talked to in-person or on the phone).
Step 4 **The measurement procedure [see figure below]**	• The healthcare professional should explain the procedure, including the number of BP measurements to be obtained. • Use the arm with the higher SBP readings during an initial visit, unless a new medical condition (e.g., arm ischemia) has developed in the interim in that arm. • ≥2 measurements should be obtained at least 30 seconds apart; the values should be averaged and recorded.

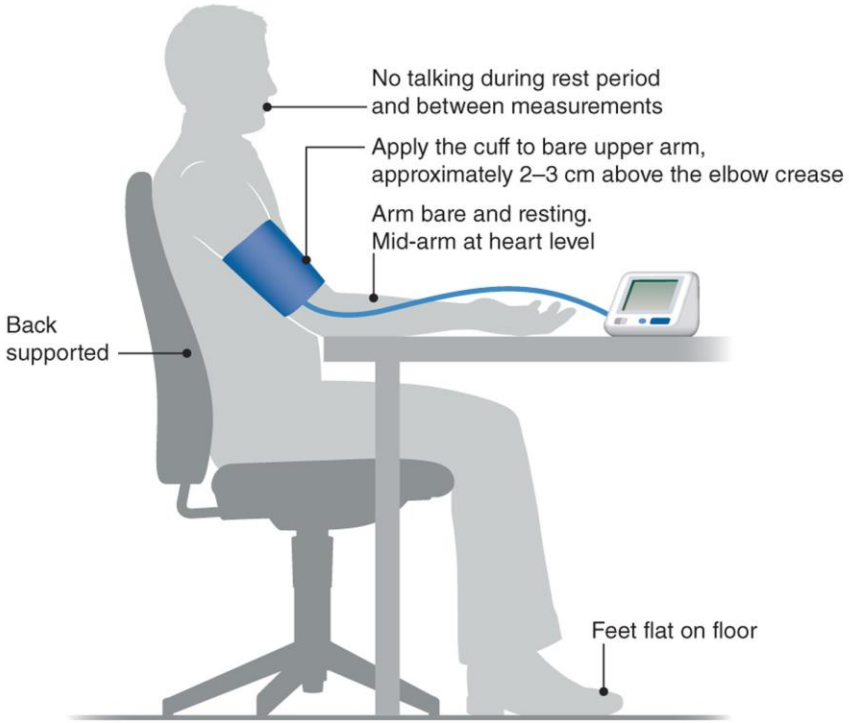
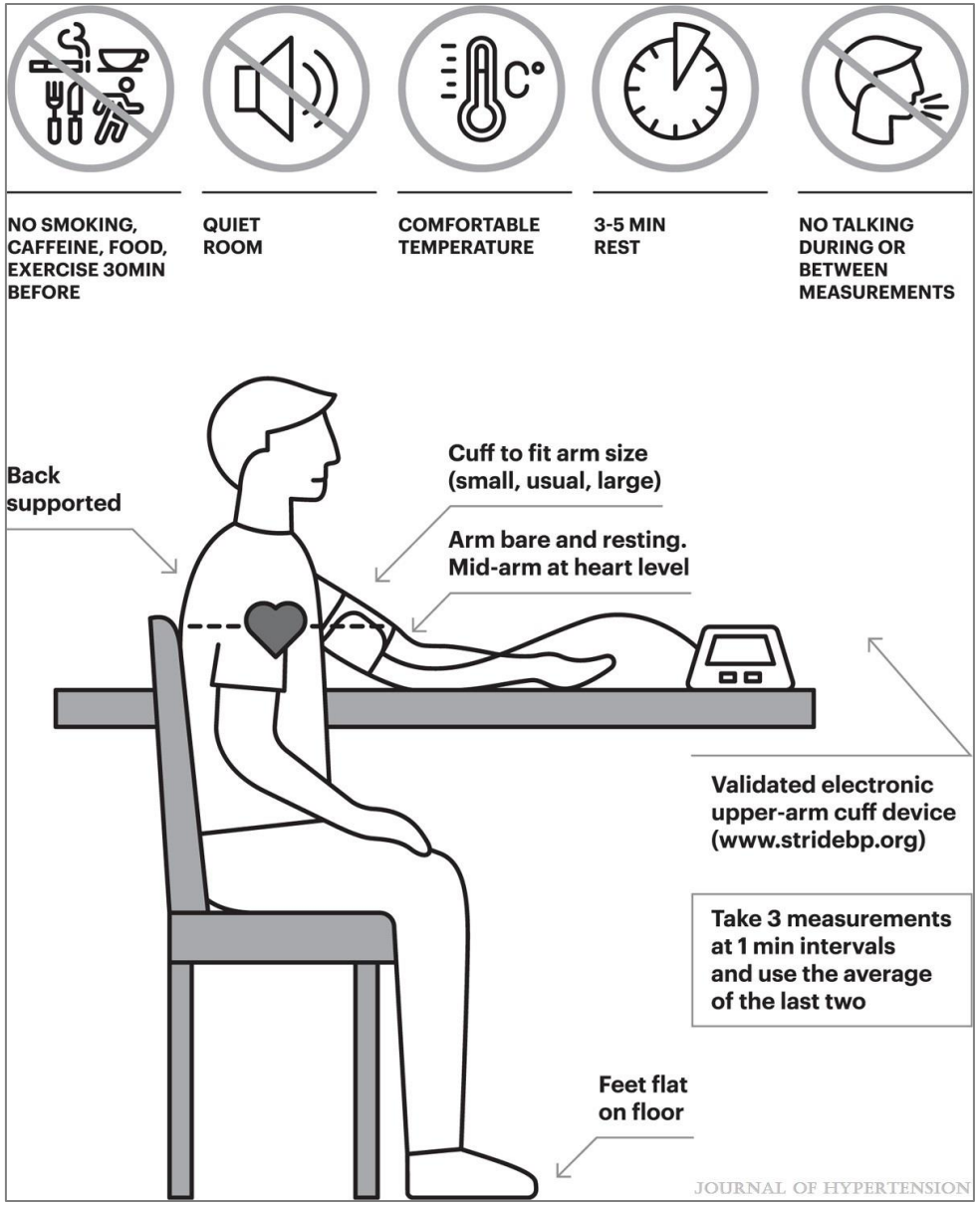


FIGURE 2



2021 European Society of Hypertension practice guidelines for office and out-of-office blood pressure measurement

Stergiou, George S.; Palatini, Paolo; Parati, Gianfranco; O'Brien, Eoin; Januszewicz, Andrzej; Lurbe, Empar; Persu, Alexandre; Mancia, Giuseppe; Kreutz, Reinhold

Journal of Hypertension39(7):1293-1302, July 2021.

doi: 10.1097/HJH.0000000000002843

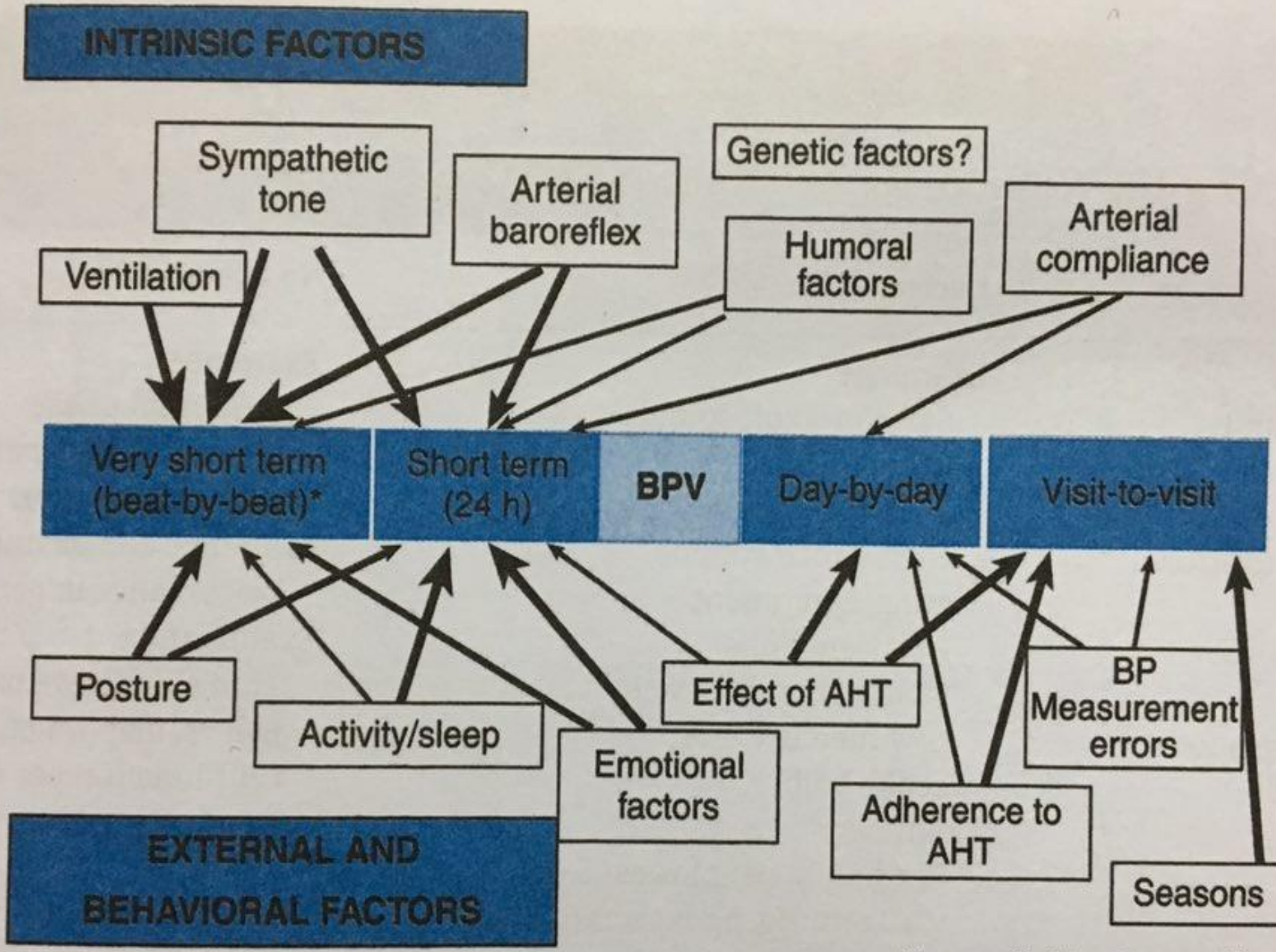
Poster of OBP measurement methodology.

Increases BP	Decreases BP	No Effect on BP
Examinee	Examinee	Examinee
Soft Korotkoff sounds	Soft Korotkoff sounds	Menstrual phase
Pseudohypertension	Recent meal	Chronic caffeine ingestion
White-coat reaction	Missed auscultatory gap	Cuff self-inflation
Paretic arm (due to stroke)	High stroke volume	Examinee and examiner
Pain, anxiety	Setting, equipment	Discordance in gender or race
Acute smoking	Noisy environs	Examination
Acute caffeine	Faulty aneroid device	Thin shirtsleeve under cuff
Acute ethanol ingestion	Low mercury level	Bell vs. diaphragm
Distended bladder	Leaky bulb	Cuff inflation per se
Talking, signing	Examiner	Hour of day (during work hours)
Setting, equipment	Reading to next lowest 5 or 10 mm Hg, or expectation bias	
Cold environment	Impaired hearing	
Leaky bulb valve	Examination	
Examination	Resting for too long	
Cuff too narrow	Arm above heart level	
Arm below heart level	Too rapid deflation	
Too-short rest period	Excess bell pressure	
Arm, back unsupported	Parallax error (aneroid)	
Parallax error		
Using phase IV (adult)		

Modified from Reeves RA. Does this patient have hypertension? *JAMA* 1995;273:1211–1218.

Average Changes in BP Associated with Commonly Occurring Activities, Relative to BP while Relaxing

Activity	Systolic BP (mm Hg)	Diastolic BP (mm Hg)
Meetings	+20.2	+15.0
Work	+16.0	+13.0
Transportation	+14.0	+9.2
Walking	+12.0	+5.5
Dressing	+11.5	+9.5
Chores	+10.7	+6.7
Telephone	+9.5	+7.2
Eating	+8.8	+9.6
Talking	+6.7	+6.7
Desk work	+5.9	+5.3
Reading	+1.9	+2.2
Business (at home)	+1.6	+3.2
Television	+0.3	+1.1
Relaxing	0.0	0.0
Sleeping	−10.0	−7.6


INTRINSIC FACTORS
Sympathetic tone
Arterial baroreflex
Genetic factors?
Arterial compliance
Humoral factors
Ventilation
Very short term (beat-by-beat)*
Short term (24 h)
BPV
Day-by-day
Visit-to-visit
Posture
Activity/sleep
Emotional factors
Effect of AHT
BP Measurement errors
Adherence to AHT
Seasons
EXTERNAL AND BEHAVIORAL FACTORS
*Assessed in laboratory condition

Guidelines for Measurement of BP in the Office

Patient Conditions

Posture

- Initially, particularly in those >65 years old or, with diabetes, or receiving antihypertensive therapy, check for postural changes by taking readings after 5 min supine, then immediately and 2 min after standing
- For routine follow-up, the patient should sit quietly with the arm bared and supported at the level of the heart and the back resting against a chair. The length of time before measurement is uncertain, but most guidelines recommend at least 1 min.

Circumstances

- No caffeine or smoking within 30 min preceding the reading
- A quiet, warm setting

Equipment

Cuff size

- The bladder should encircle at least 80% of the circumference and cover two-thirds of the length of the arm
- A too-small bladder may cause falsely high readings

Manometer

- Either a mercury, recently calibrated aneroid or validated electronic device
- Since mercury is hazardous, oscillometric devices are being used increasingly, and they do not require listening for Korotkoff sounds

Stethoscope

- The bell of the stethoscope should be used, avoiding excess pressure

Infants

- Use ultrasound (e.g., the Doppler method)

Technique

Number of readings

- On each occasion, take at least two readings, separated by as much time as is practical; if readings vary >5 mm Hg, take additional readings until two are close
- For diagnosis, obtain three sets of readings at least 1 wk apart
- Initially, take pressure in both arms preferably simultaneously; if the pressures differ, use the arm with the higher pressure
- If the arm pressure is elevated, take the pressure in one leg, particularly in patients <30 years old

Performance

- Inflate the bladder quickly to a pressure 20 mm Hg above the systolic pressure, recognized by the disappearance of radial pulse, to avoid an auscultatory gap
- Deflate the bladder 3 mm Hg/s
- Record the Korotkoff phase I (appearance) and phase V (disappearance)
- If the Korotkoff sounds are weak, have the patient raise the arm and open and close the hand 5–10 times, then inflate the bladder quickly

Recordings

- Note the pressure, patient position, the arm, and the cuff size (e.g., 140/90, seated, right arm, and large adult cuff, respectively)

Technique – cont'd

- Place stethoscope gently over brachial artery
- Inflate mercury rapidly, 30 mmHg above occlusion of pulse
- Deflate very slowly, 2 mmHg per second
- Record first of regular sounds (systolic BP)
- Record diastolic as disappearance of sound
- Record measurements to the nearest 2 mmHg
- Repeat twice more and average last two.

BP measurement - observer

- Mercury column not level with the eyes
- Failure to hear the Korotkoff sounds
- Wrong diastolic endpoint (K4 or K5)
- Subjective detection of Korotkoff sounds
- Rapid cuff deflation
- Single one off reading.

Stethoscope

- Good quality
- Short tubing
- Well fitting ear pieces (cleaned regularly)
- Place gently over the brachial artery
- Avoid touching the cuff and tubing.

Posture

- Routine - seated
- Standing in patients with symptoms or diabetic (diabetic nephropathy) and the elderly
- Supine position unnecessary, inconvenient and cuff position often below the heart.

BP measurement - patient

- Anxiety and unfamiliarity
- Animated discussion about the latest news
- Ambient temperature
- Full bladder!
- Postural hypotension
- Difference between arms.

Patient

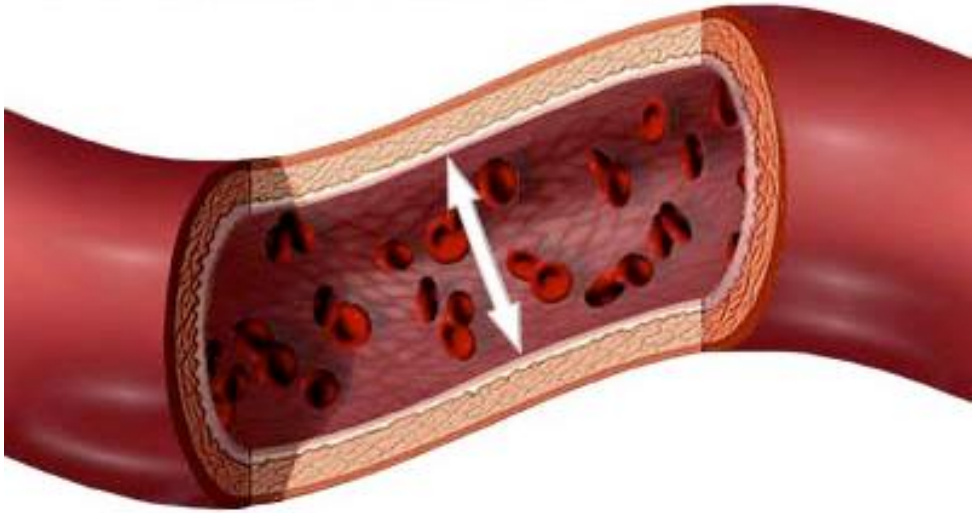
- Consent is taken as read when patient rolls up sleeve
- Explain the procedure, that it may be a little uncomfortable and that several readings will be taken
- Seated, relaxed, not speaking
- Tight arm clothing removed
- Arm supported (not hyper extended) with cuff level with the heart.

Explanation to the patient

- Tell the patient their blood pressure reading
- Write BP down – use co-operation cards
- Give relevant leaflets/booklets on life style issues (not too many at a time)
- Reassure patient that this is a risk factor not a disease (unless left untreated)
- Do not lose to follow-up.

What is Blood Pressure?

- Blood Pressure is a measurement of the force against the walls of the arteries as the heart pumps blood throughout the body



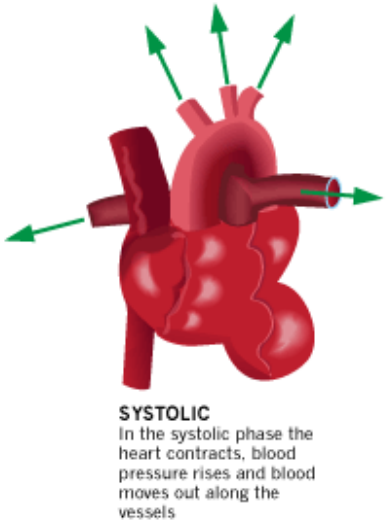
- Blood pressure is measured in mmHg (millimeters of mercury)
- 1,000 Pa is about 7 mmHg!

What is Blood Pressure?

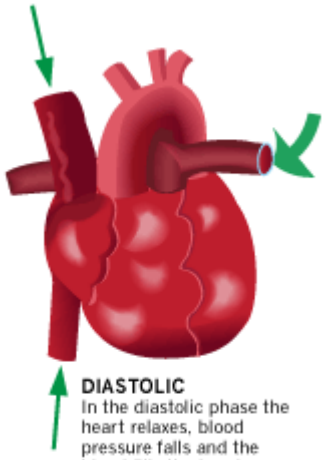
- The blood pressure reading is taken in 2 numbers: **systolic** and **diastolic**.

Measure of pressure as the heart is beating

Systolic



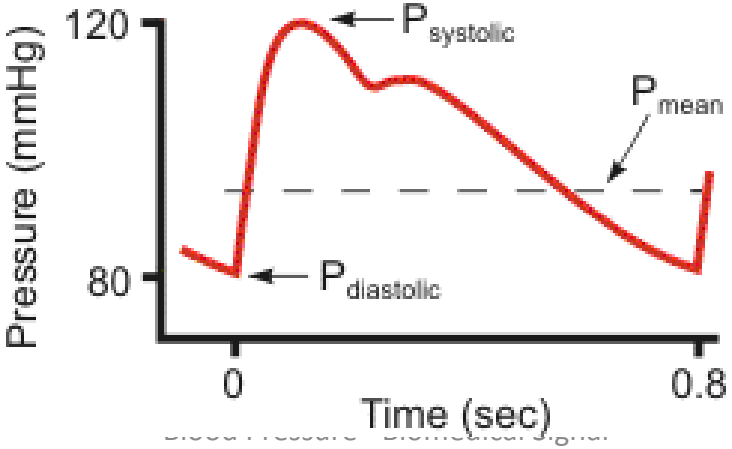
SYSTOLIC
In the systolic phase the heart contracts, blood pressure rises and blood moves out along the vessels



DIASTOLIC
In the diastolic phase the heart relaxes, blood pressure falls and the blood fills the heart

Diastolic

Measure of pressure while the heart is at rest between beating



How to measure?

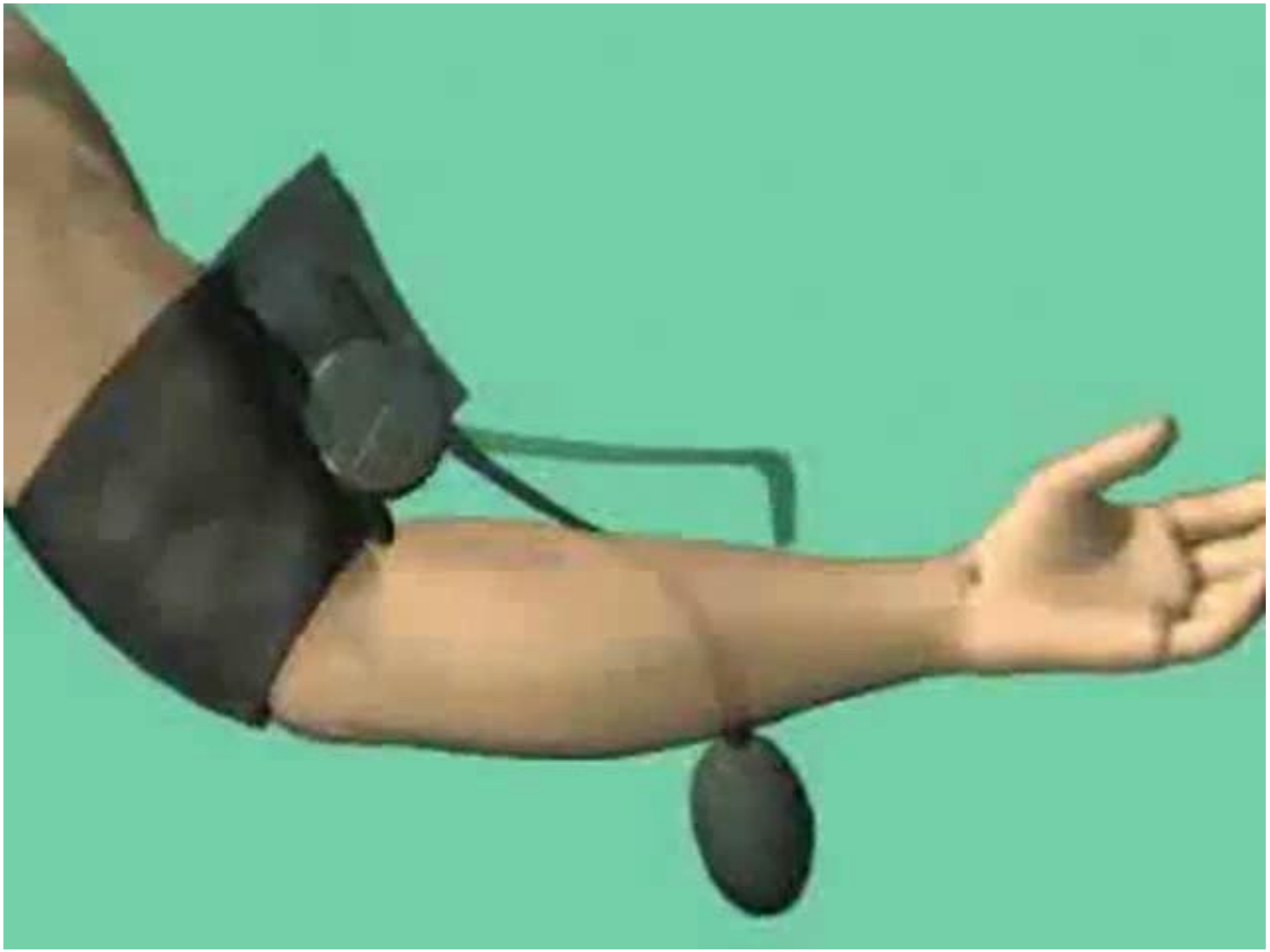
- Non-invasive blood pressure
  - Auscultation

Mercury sphygmomanometer
+ stethoscope

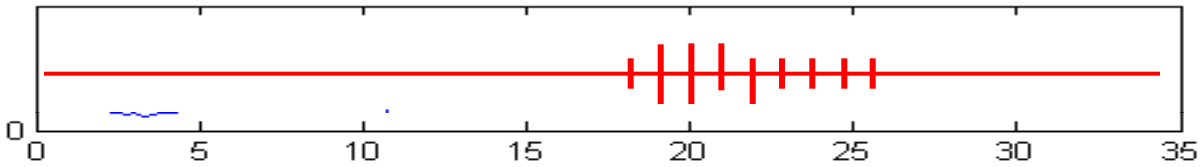
Mechanical manometer
+ stethoscope

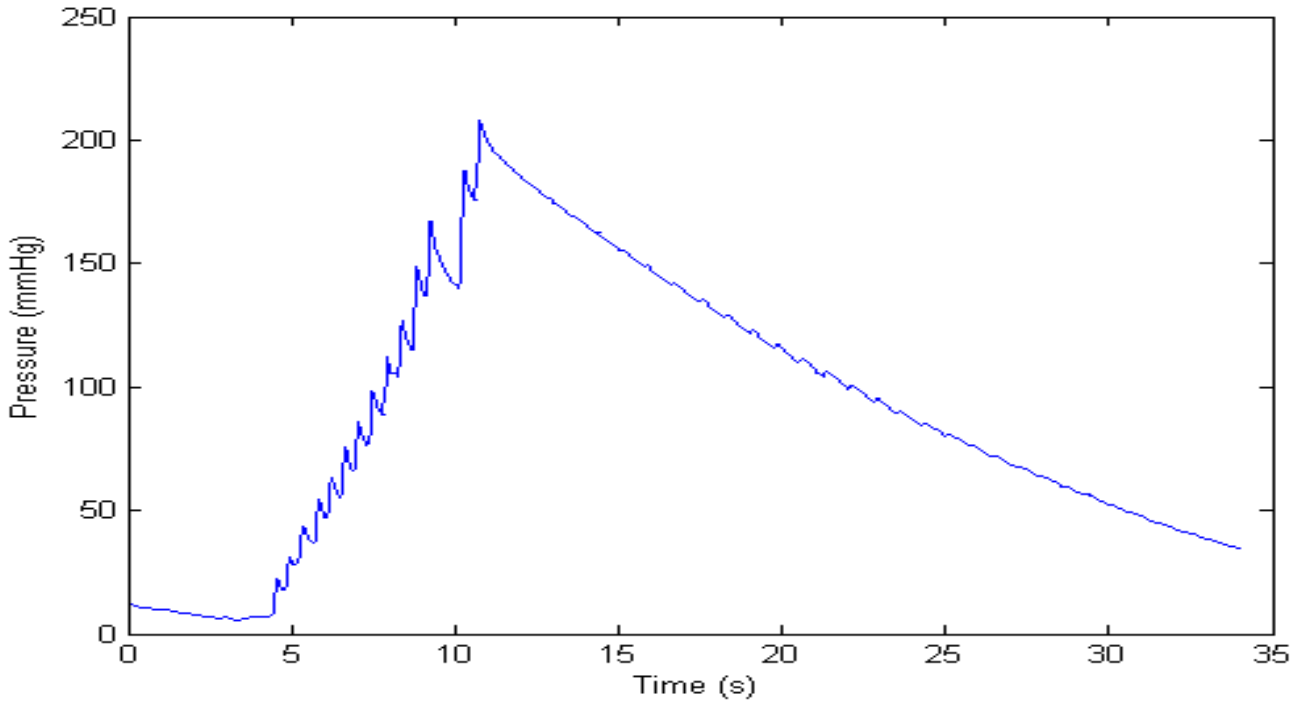
  - Oscillometry

How to measure?

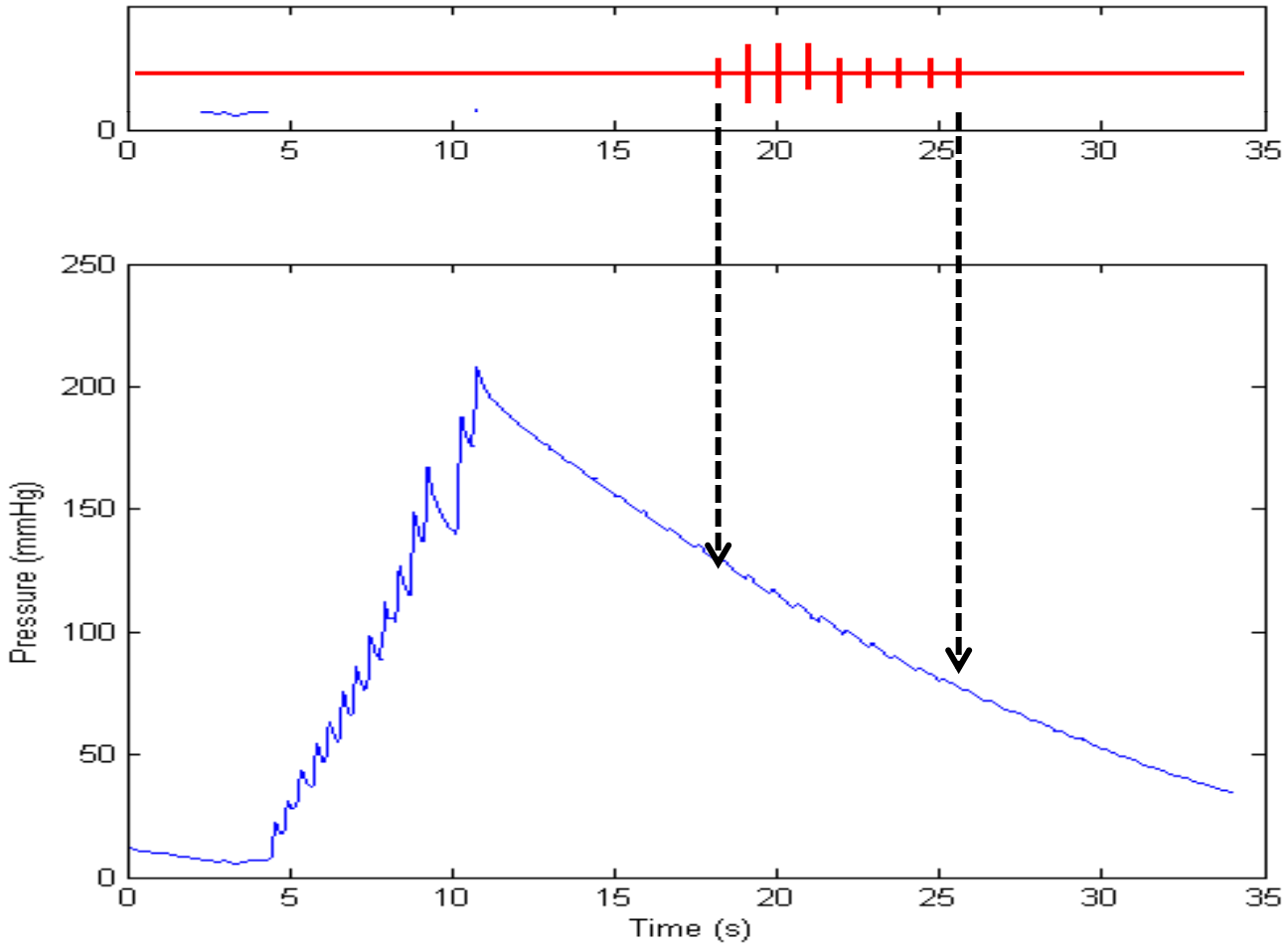


The auscultation method

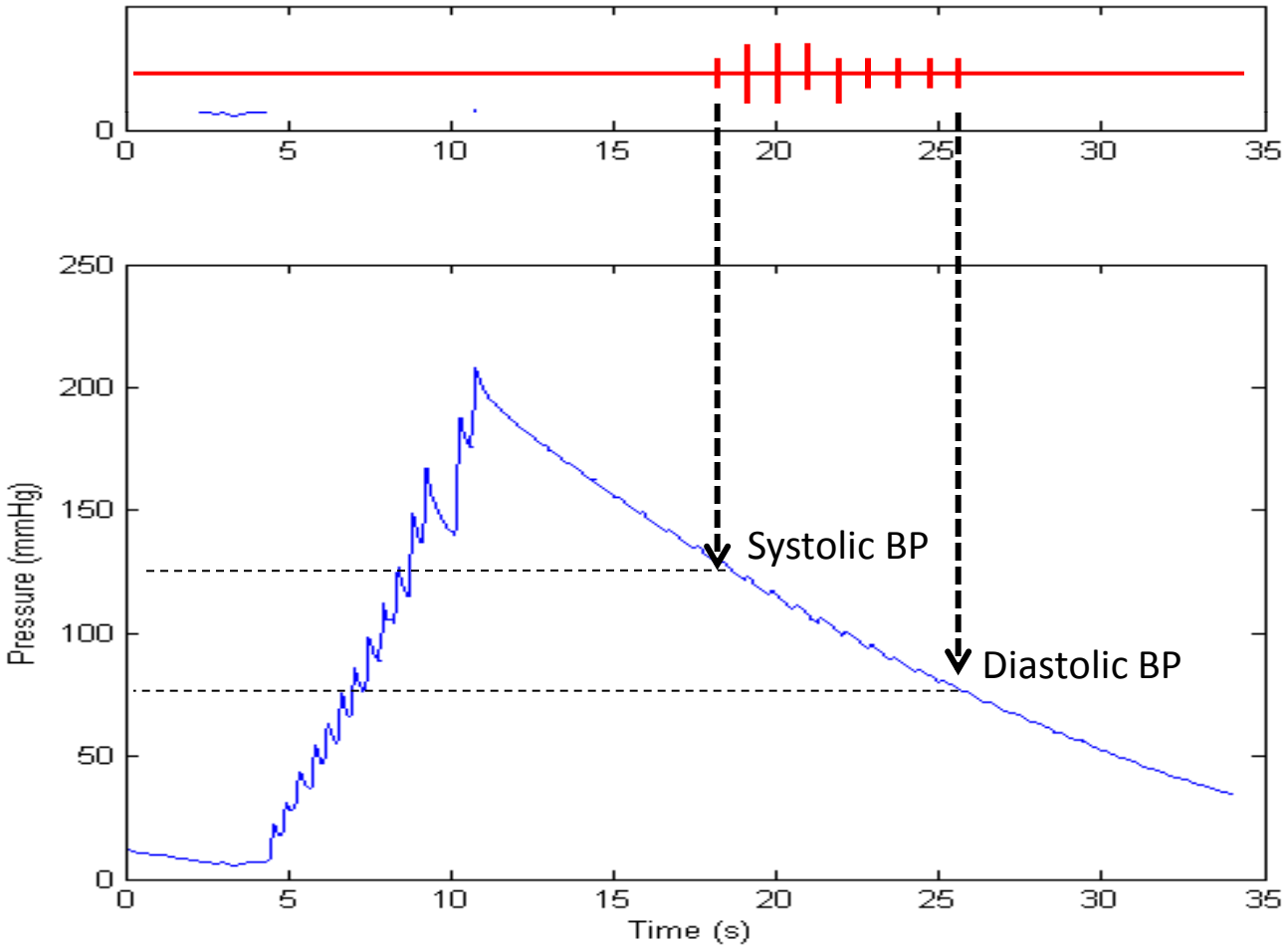




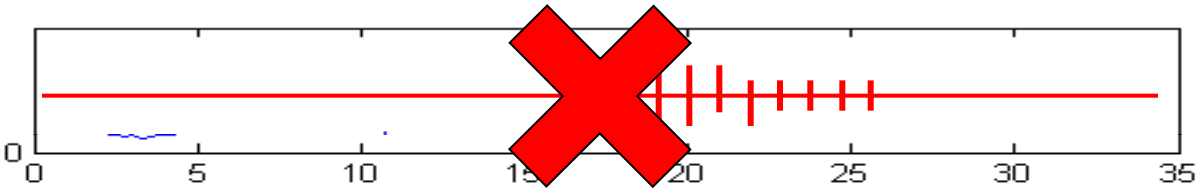
The auscultation method

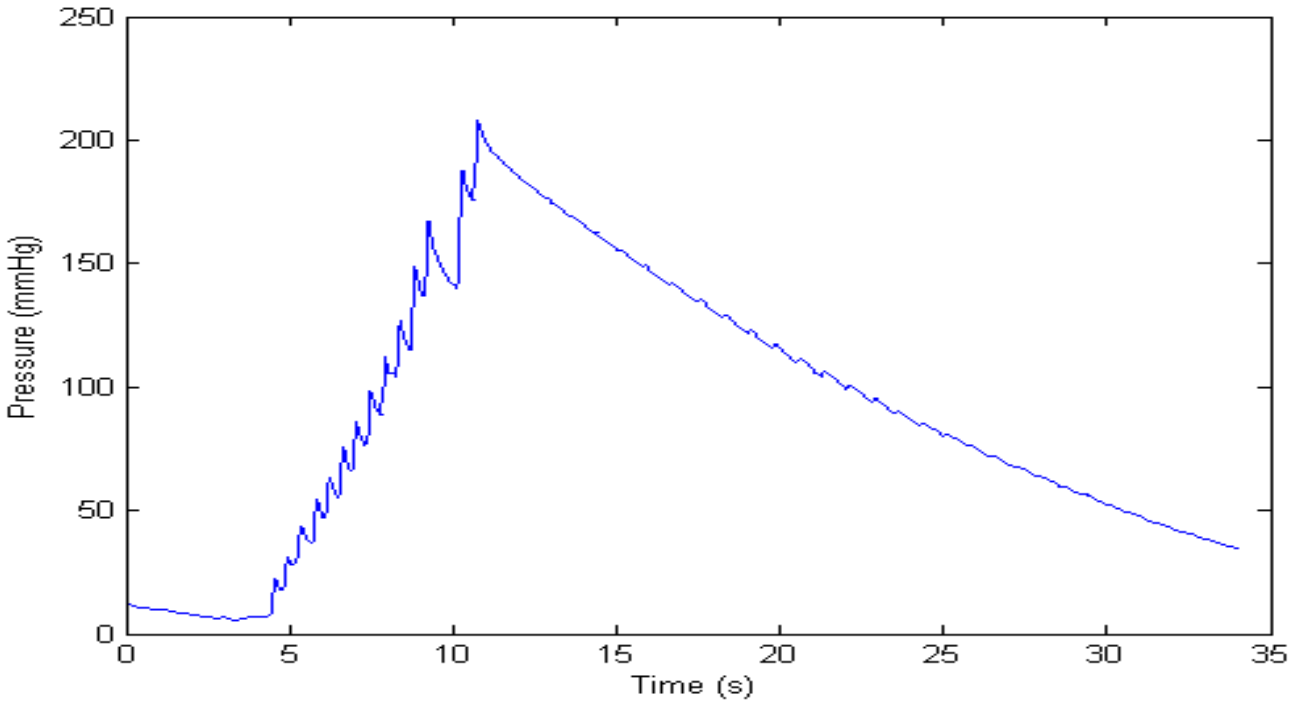


The auscultation method



The oscillometric method



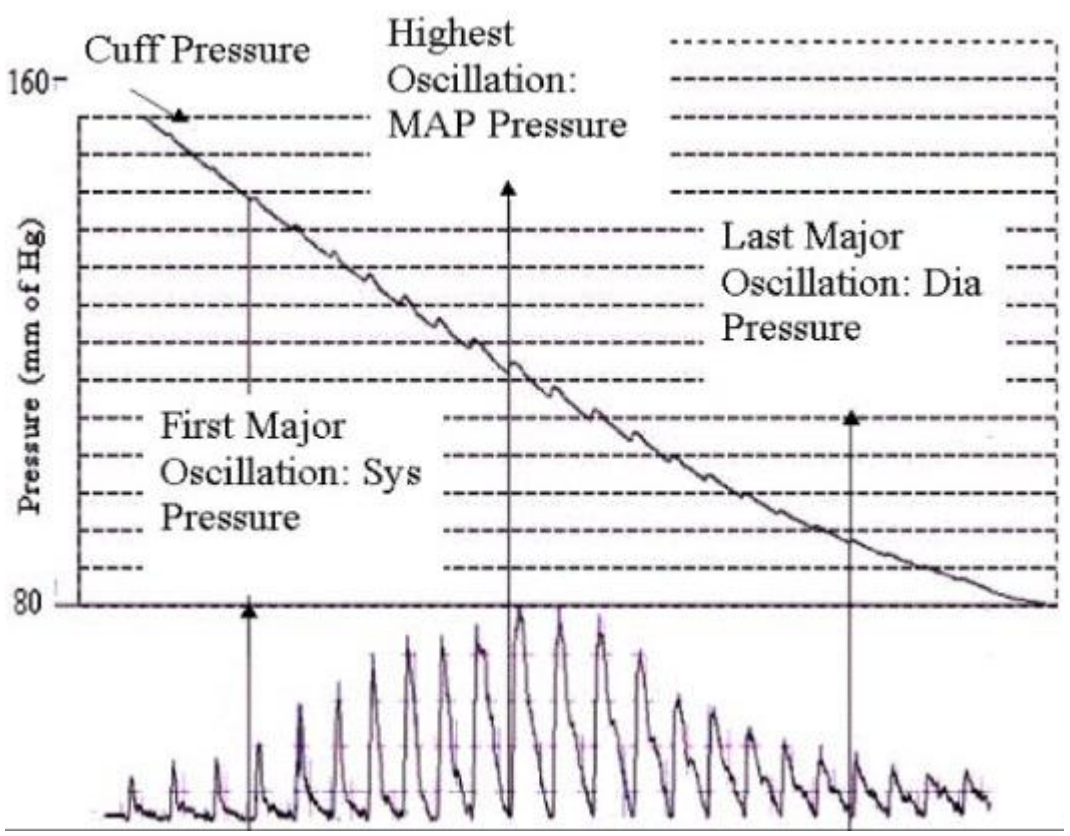


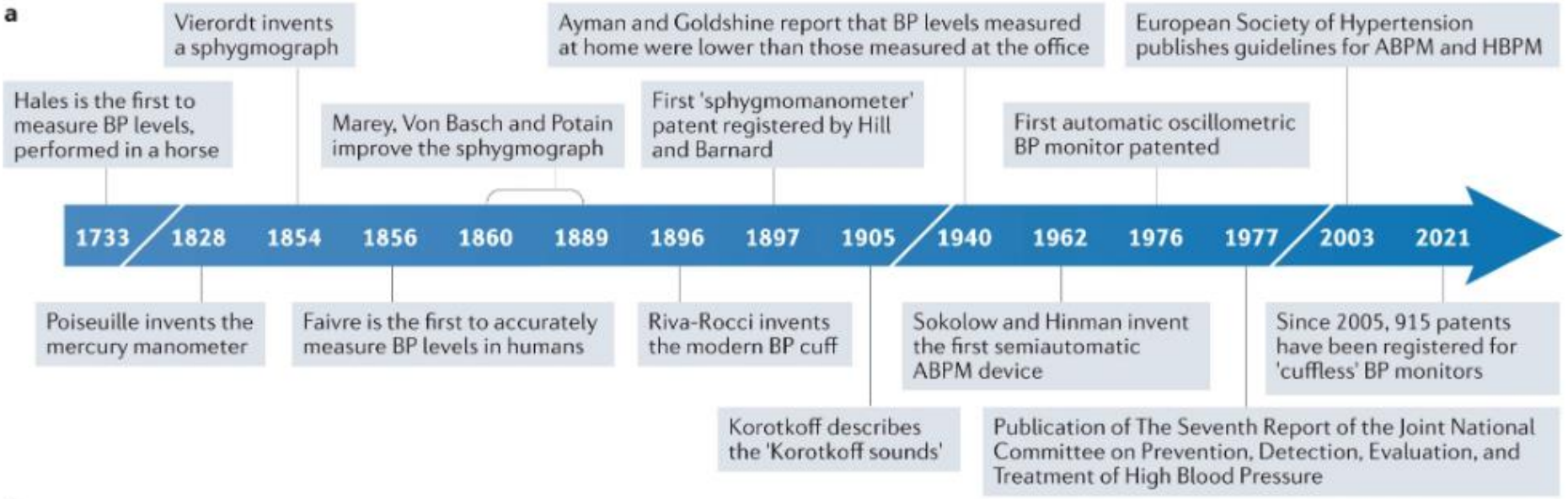
The oscillometric method

- It is based on the change of the magnitude of oscillation

- MAP – Mean Arterial Pressure

$$MAP \simeq \frac{2}{3}(DP) + \frac{1}{3}(SP)$$




a
Hales is the first to measure BP levels, performed in a horse
Vierordt invents a sphygmograph
Marey, Von Basch and Potain improve the sphygmograph
First 'sphygmomanometer' patent registered by Hill and Barnard
Ayman and Goldshine report that BP levels measured at home were lower than those measured at the office
First automatic oscillometric BP monitor patented
European Society of Hypertension publishes guidelines for ABPM and HBPM
1733
1828
1854
1856
1860
1889
1896
1897
1905
1940
1962
1976
1977
2003
2021
Poiseuille invents the mercury manometer
Faivre is the first to accurately measure BP levels in humans
Riva-Rocci invents the modern BP cuff
Korotkoff describes the 'Korotkoff sounds'
Sokolow and Hinman invent the first semiautomatic ABPM device
Publication of The Seventh Report of the Joint National Committee on Prevention, Detection, Evaluation, and Treatment of High Blood Pressure
Since 2005, 915 patents have been registered for 'cuffless' BP monitors
b

Automated office BP measurement

- Multiple reading when the pt siiting and resting alone.
- It better predicts the results of ABPM than traditional office BP measurement and may reduce white coat effect.
- It’s threshold is <135/85 mmHg.

AOBP should now be the preferred method for recording BP in routine clinical practice

Research

JAMA Internal Medicine | Original Investigation

Comparing Automated Office Blood Pressure Readings With Other Methods of Blood Pressure Measurement for Identifying Patients With Possible Hypertension

A Systematic Review and Meta-analysis

Michael Roerecke, PhD; Janusz Kaczorowski, PhD; Martin G. Myers, MD, FRCPC

IMPORTANCE Automated office blood pressure (AOBP) measurement involves recording several blood pressure (BP) readings using a fully automated oscillometric sphygmomanometer with the patient resting alone in a quiet place. Although several studies have shown AOBP measurement to be more accurate than routine office BP measurement and not subject to a "white coat effect," the cumulative evidence has not yet been systematically reviewed.

Supplemental content

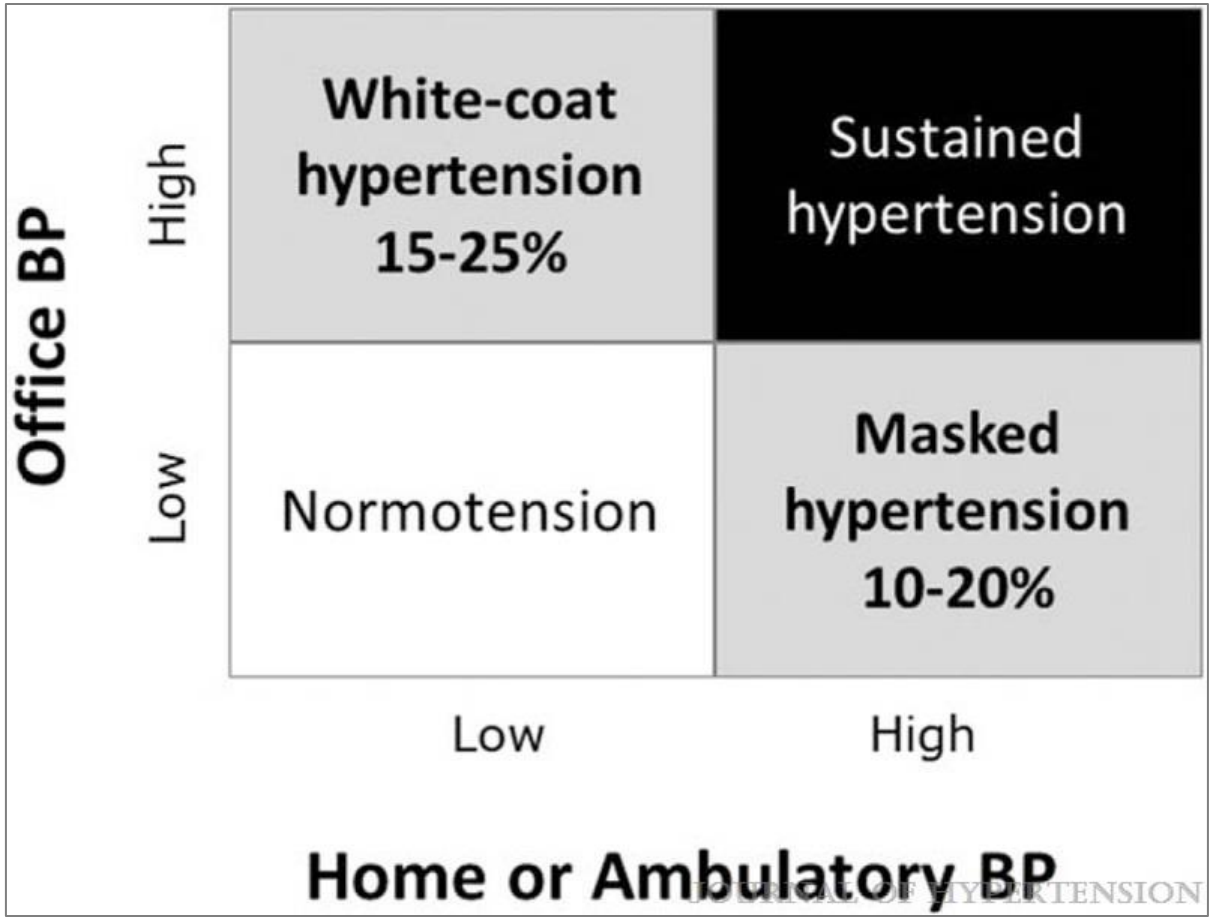
AOBP

Findings This systematic review and meta-analysis of 31 articles comprising 9279 participants compared automated office blood pressure with awake ambulatory blood pressure, a standard for predicting cardiovascular risk. Mean automated office blood pressure readings **were similar to the awake ambulatory blood pressure readings and did not exhibit the "white coat effect"** associated with routine office blood pressure measurement

AOBP

CONCLUSIONS AND RELEVANCE Automated office blood pressure readings, only when recorded properly with the patient sitting alone in a quiet place, are more accurate than office BP readings in routine clinical practice and are similar to awake ambulatory BP readings, with mean AOBP being devoid of any white coat effect. There has been some reluctance among physicians to adopt this technique because of uncertainty about its advantages compared with more traditional methods of recording BP during an office visit. Based on the evidence, **AOBP should now be the preferred method for recording BP in routine clinical practice**.

FIGURE 1



2021 European Society of Hypertension practice guidelines for office and out-of-office blood pressure measurement

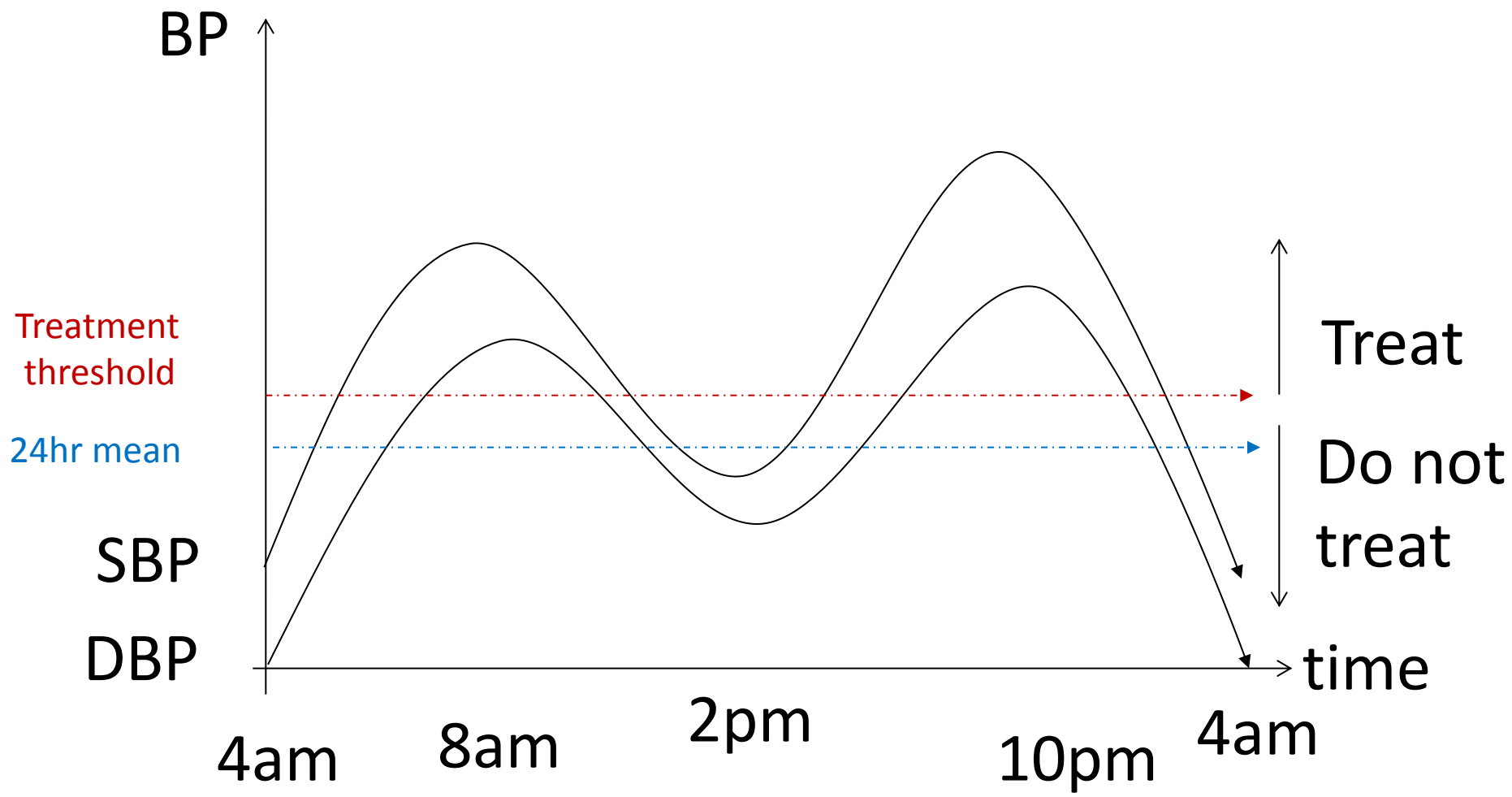
Stergiou, George S.; Palatini, Paolo; Parati, Gianfranco; O'Brien, Eoin; Januszewicz, Andrzej; Lurbe, Empar; Persu, Alexandre; Mancia, Giuseppe; Kreutz, Reinhold

Journal of Hypertension39(7):1293-1302, July 2021.

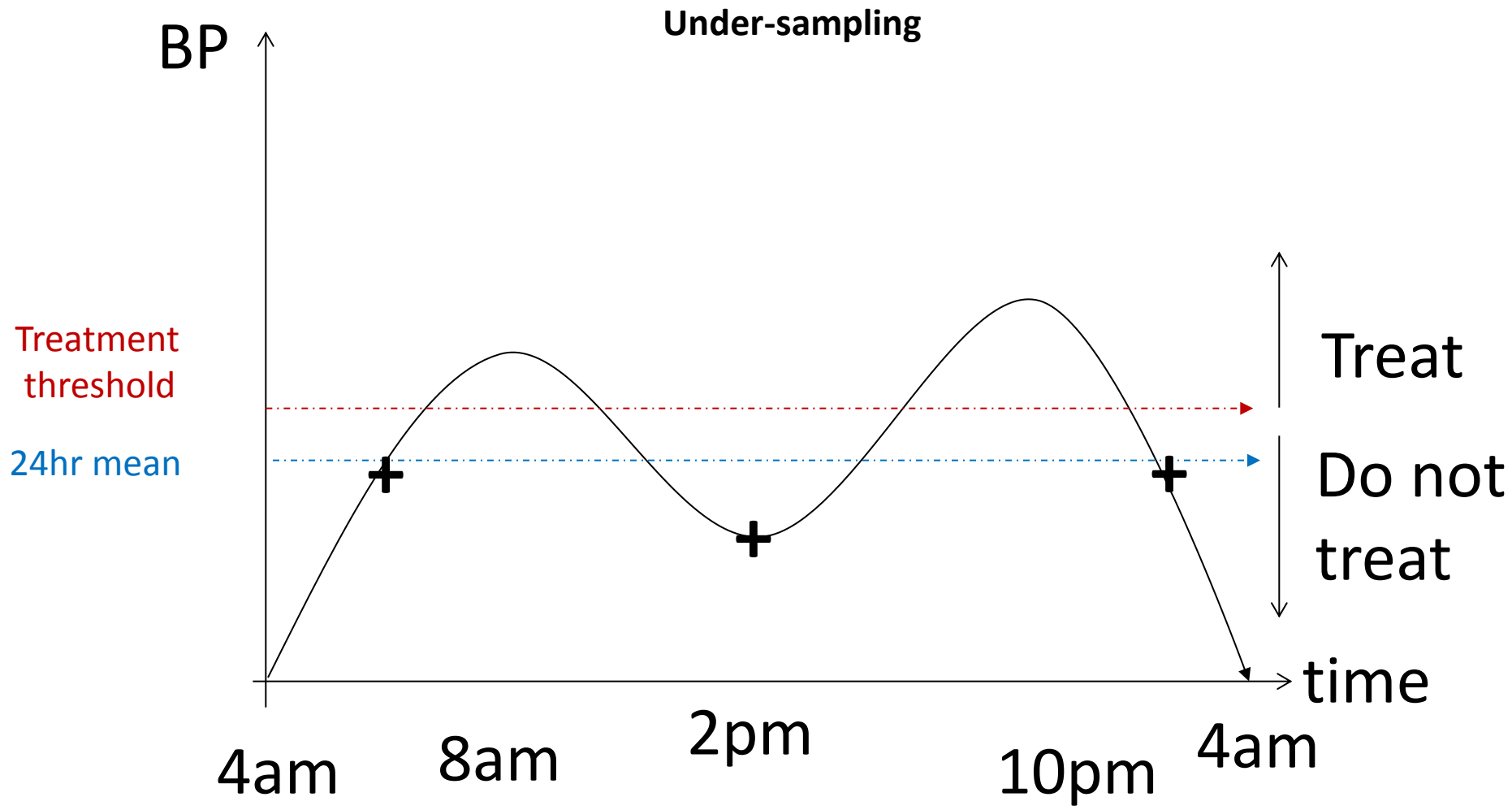
doi: 10.1097/HJH.0000000000002843

Classification of patients attending BP clinics according to their office and out-of-office BP measurements.

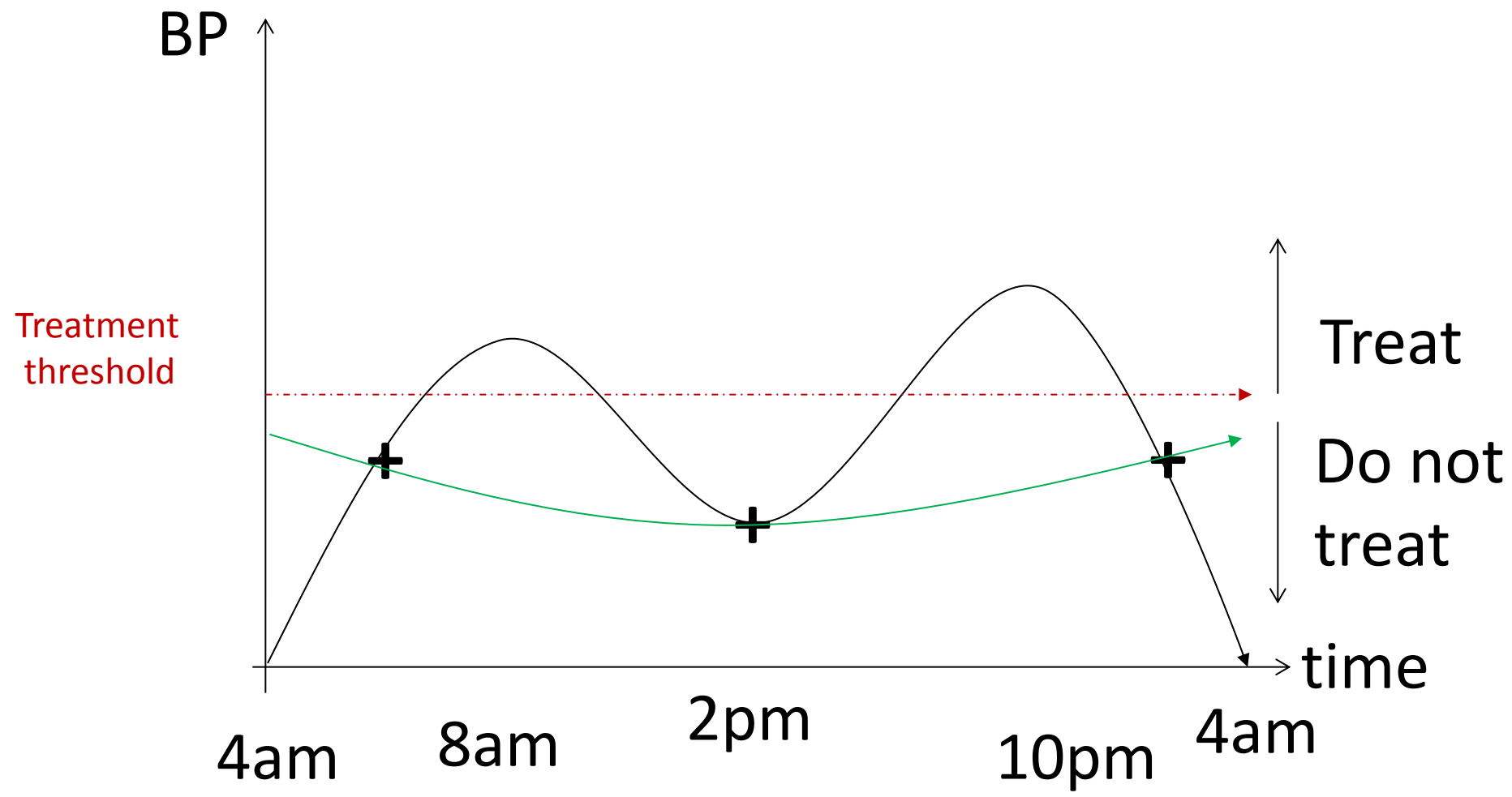
How often should we measure?

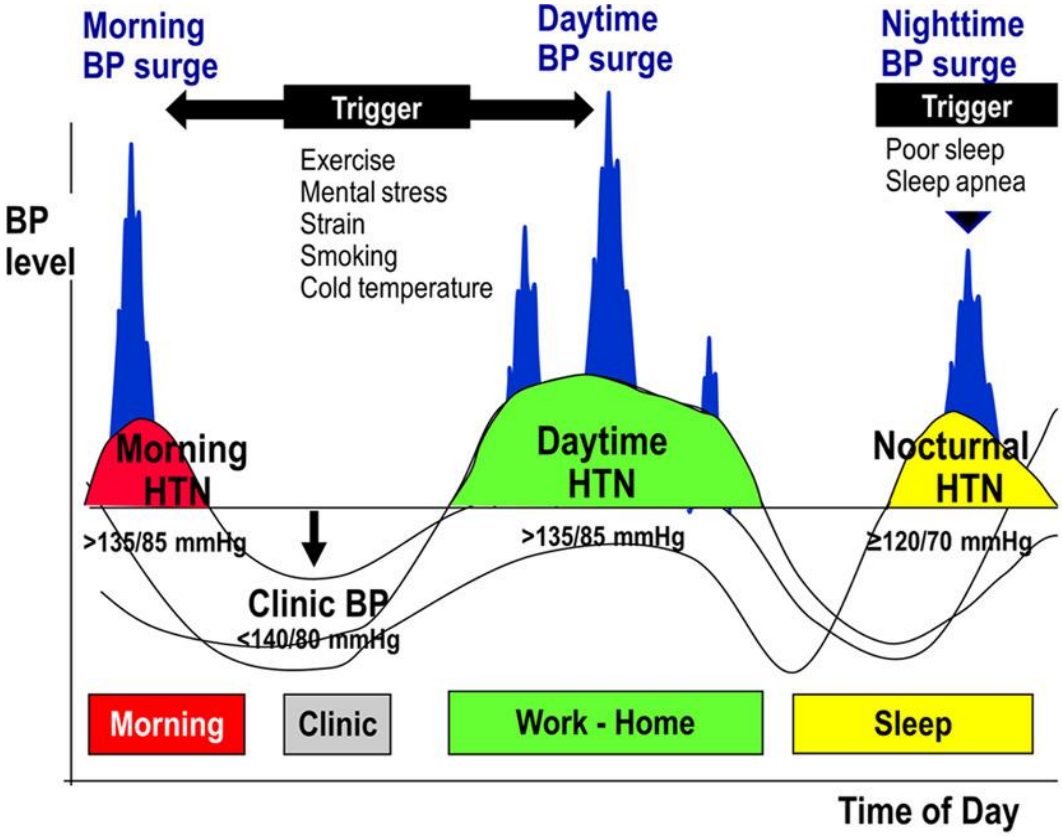


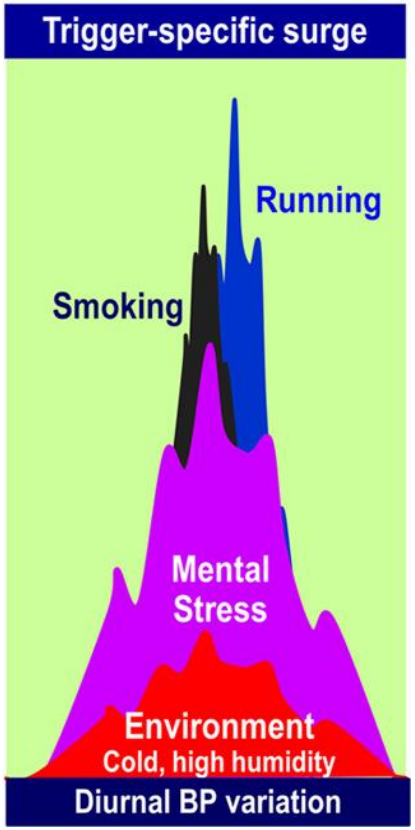
How often should we measure?



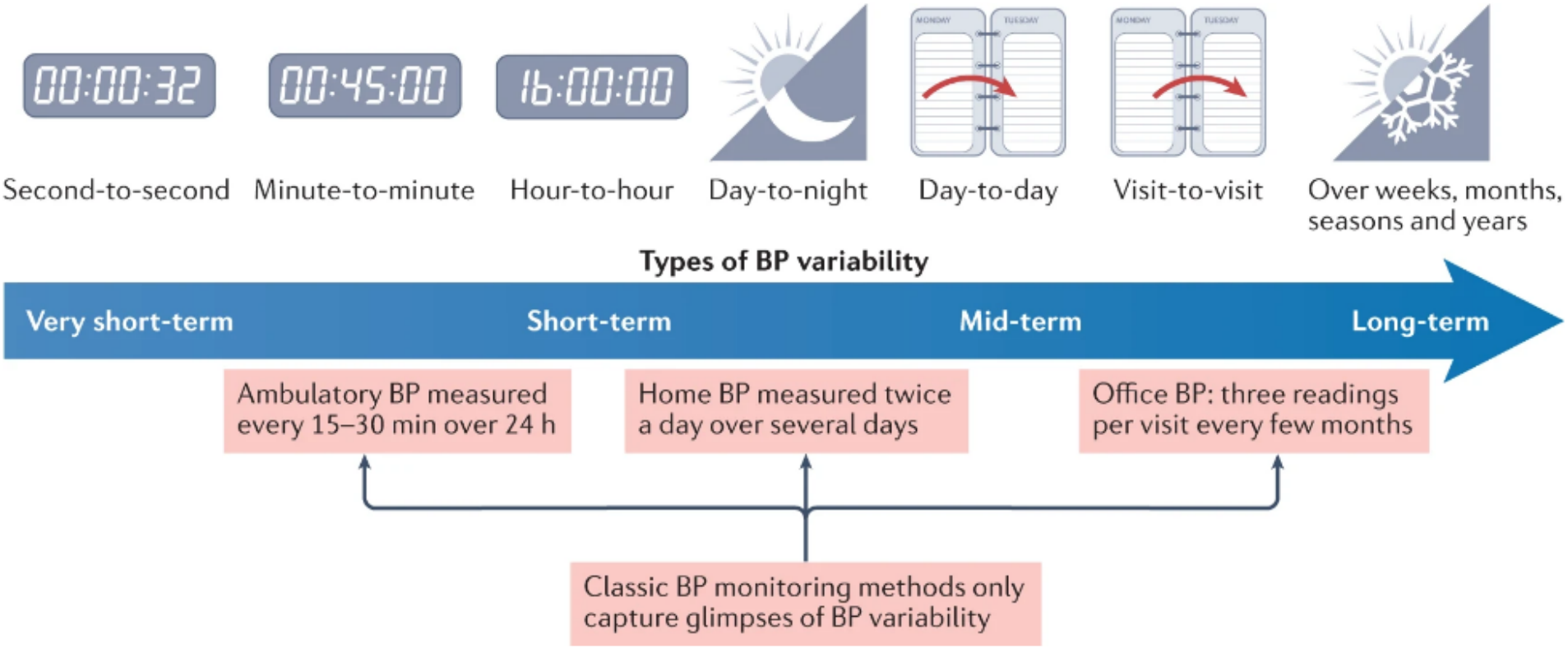
How often should we measure?







Kazuomi Kario. Hypertension. Management of Hypertension in the Digital Era, Volume: 76, Issue: 3, Pages: 640-650, DOI: (10.1161/HYPERTENSIONAHA.120.14742)


00:00:32
00:45:00
16:00:00
Second-to-second
Minute-to-minute
Hour-to-hour
Day-to-night
Day-to-day
Visit-to-visit
Over weeks, months, seasons and years
Types of BP variability
Very short-term
Short-term
Mid-term
Long-term
Ambulatory BP measured every 15–30 min over 24 h
Home BP measured twice a day over several days
Office BP: three readings per visit every few months
Classic BP monitoring methods only capture glimpses of BP variability

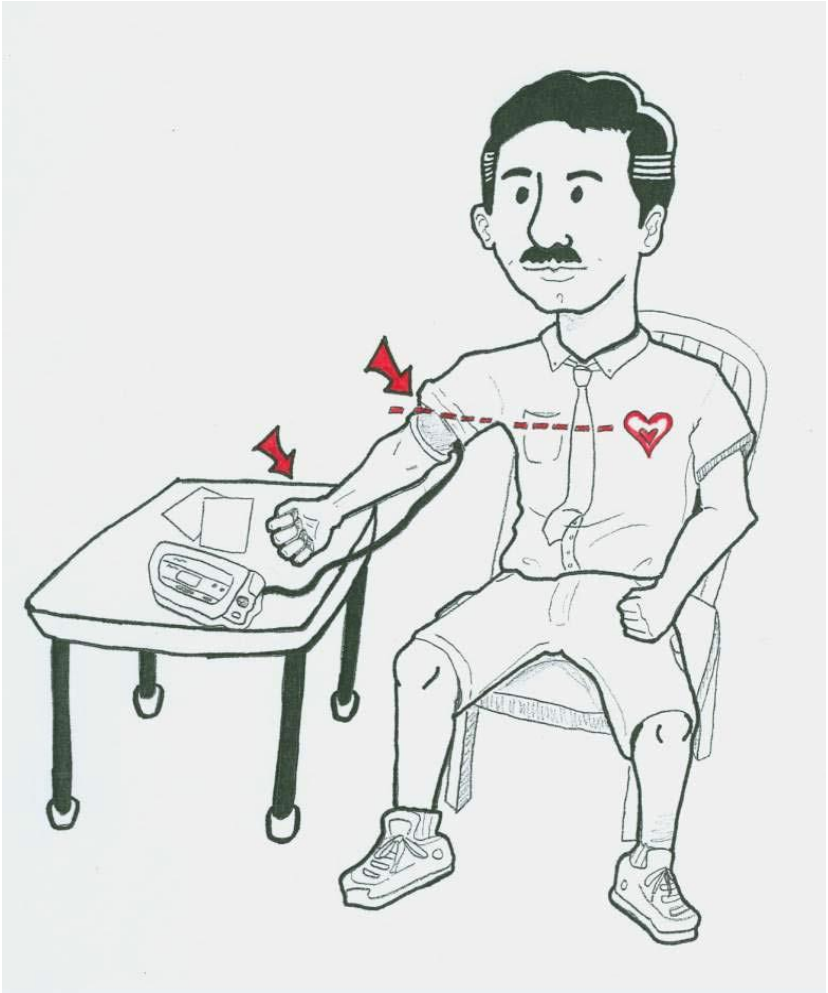
Home BP Monitoring

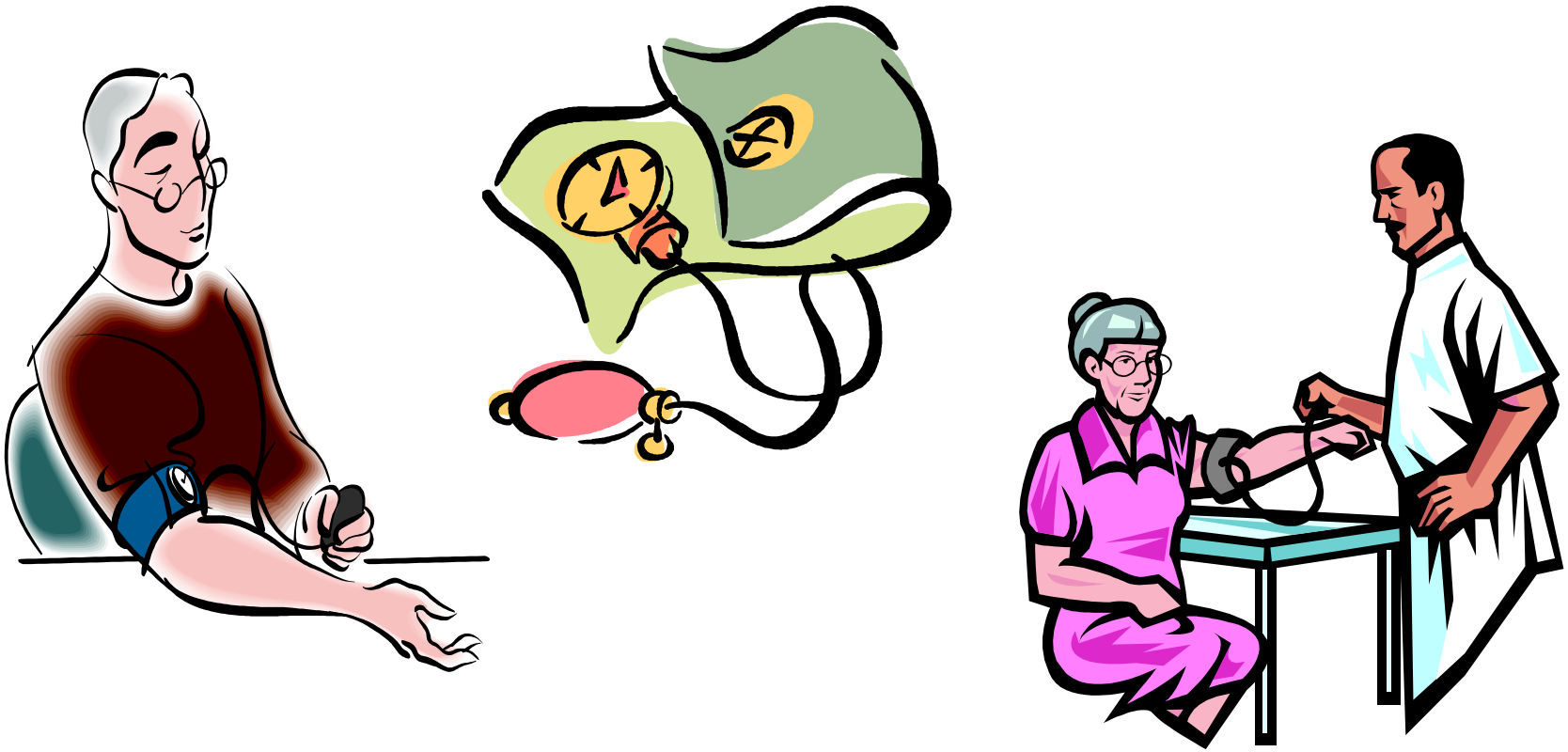
- Self-measured blood pressure monitoring (SMBP) plus additional support is one strategy that can be implemented in communities to reduce the risk of disability or death due to high blood pressure.
- SMBP is defined as the regular measurement of blood pressure by the patient outside the clinical setting, either at home or elsewhere.
- It is sometimes known as “home blood pressure monitoring.”

- Patients should take at least two, preferably three readings, and record them all. The interval between can be as little as a minute.
- Readings should be routinely taken in the morning (before medication) and at night before bed.
- Patients need to be educated about the variability of readings.
- The recommendation is to take ≥ 2 morning readings and 2 evening readings every day for 1 week (discarding the readings of the first day. This gives a total of 12 readings on which to make clinical decisions on.

Correct Technique for home blood pressure readings

- Sit calmly with back support, feet flat on floor for 5 minutes before taking a reading.
- Upper arm should be bare.
- When taking a reading the arm with cuff should be supported on a firm surface at heart level.
- Caffeine, smoking, and exercise should be avoided for at least 30 minutes before the reading is taken.
- The cuff should fit snugly.





The upper limit of normal for home pressure is **135/85 mm Hg**. This corresponds to an office blood pressure of **140/90 mmHg**

Value of Home Blood Pressure Monitoring

- Five prospective studies have compared home and office BP for predicting cardiovascular outcomes.
- All 5 found that home BP is a significant predictor, and 4/5 that it is stronger than office BP.
- Other studies have shown that home BP predicts target organ damage better than office BP.
- **Patients who monitor their home BP may be more likely to take their medications regularly**.

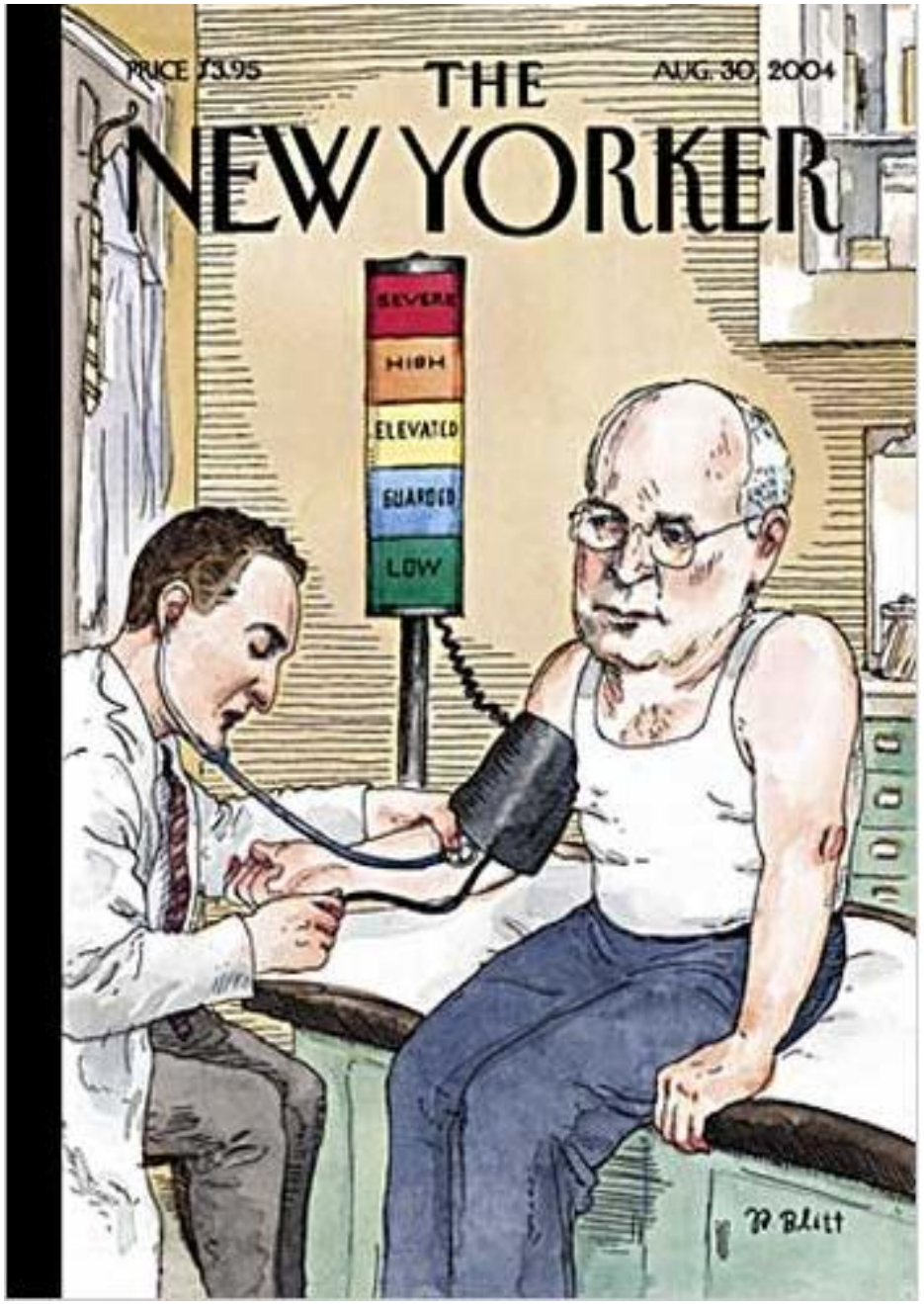
AHA-Hypertension 2008

HBPM

- Is more predictive of adverse outecome(stroke, ESRD) than office BP measurement.
- Repeat every 3 months.

Special populations who may benefit from Home Blood Pressure Monitoring

- Elderly: BP variability tends to be high, and white coat hypertension is common.
- Diabetics: Tight BP control is important and home monitoring may help achieve this.
- Pregnancy: The early detection of pre-eclampsia might be facilitated by HBPM.
- Chronic Kidney Disease: BP may fluctuate a lot and home monitors help with management.
- Children: White coat hypertension occurs in children, and there are some data on normal home BP levels at different ages.



A Diagnosis of Hypertension

exclusively on Physician readings is no loger acceptable

- Measurement error
- Small number of readings
- Effects of recent activities
- Expense & Inconvenience
- White coat effect

Prospective Studies Showing that Home BP Predicts CV Morbidity Better than Clinic BP

Author	Year	Population	N	Comments
Imai	1996	Population	1789	ABP & HBP predict, not CBP
Bobrie	2004	Treated	4939	HBP predicts, not CBP
Sega	2005	Population	2051	HBP predicts better than CBP

Prospective Studies Showing that Home BP Predicts CV Morbidity Better than Clinic BP

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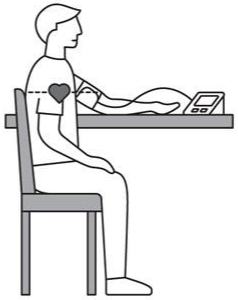
Bobrie	2004	Treated	4939	HBP predicts, not CBP
Sega	2005	Population	2051	HBP predicts better than CBP

Home monitoring should be recommended for all patients

Home Blood Pressure Monitoring

Name: _____

Date of birth: ____ /____ /_____ Device: _____



Validated electronic arm-cuff device

Before each office visit:

→ 7-day monitoring (at least 3)

→ Morning and evening, before drug intake

→ After 5 min sitting rest

→ 2 measurements with 1 min interval

Long-term follow-up:
Duplicate measurement once or twice per week or month

			Time	Systolic-Diastolic	(Pulse rate)
DAY 1 __/__/ 202_	Morning	1st	__:__	_____ - _____	(_____)
		2nd		_____ - _____	(_____)
	Evening	1st	__:__	_____ - _____	(_____)
		2nd		_____ - _____	(_____)
DAY 2 __/__/ 202_	Morning	1st	__:__	_____ - _____	(_____)
		2nd		_____ - _____	(_____)
	Evening	1st	__:__	_____ - _____	(_____)
		2nd		_____ - _____	(_____)
DAY 3 __/__/ 202_	Morning	1st	__:__	_____ - _____	(_____)
		2nd		_____ - _____	(_____)
	Evening	1st	__:__	_____ - _____	(_____)
		2nd		_____ - _____	(_____)
DAY 4 __/__/ 202_	Morning	1st	__:__	_____ - _____	(_____)
		2nd		_____ - _____	(_____)
	Evening	1st	__:__	_____ - _____	(_____)
		2nd		_____ - _____	(_____)
DAY 5 __/__/ 202_	Morning	1st	__:__	_____ - _____	(_____)
		2nd		_____ - _____	(_____)
	Evening	1st	__:__	_____ - _____	(_____)
		2nd		_____ - _____	(_____)

			Time	Systolic-Diastolic	(Pulse rate)
DAY 6 __/__/ 202_	Morning	1st	__:__	_____ - _____	(_____)
		2nd		_____ - _____	(_____)
	Evening	1st	__:__	_____ - _____	(_____)
		2nd		_____ - _____	(_____)
DAY 7 __/__/ 202_	Morning	1st	__:__	_____ - _____	(_____)
		2nd		_____ - _____	(_____)
	Evening	1st	__:__	_____ - _____	(_____)
		2nd		_____ - _____	(_____)

WRITE HERE THE AVERAGE OF ALL READINGS EXCEPT OF DAY 1: _____ - _____ (_____)

[2021 European Society of Hypertension practice guidelines for office and out-of-office blood pressure measurement]

Stergiou, George S.; Palatini, Paolo; Parati, Gianfranco; O'Brien, Eoin; Januszewicz, Andrzej; Lurbe, Empar; Persu, Alexandre; Mancia, Giuseppe; Kreutz, Reinhold

Journal of Hypertension39(7):1293-1302, July 2021.

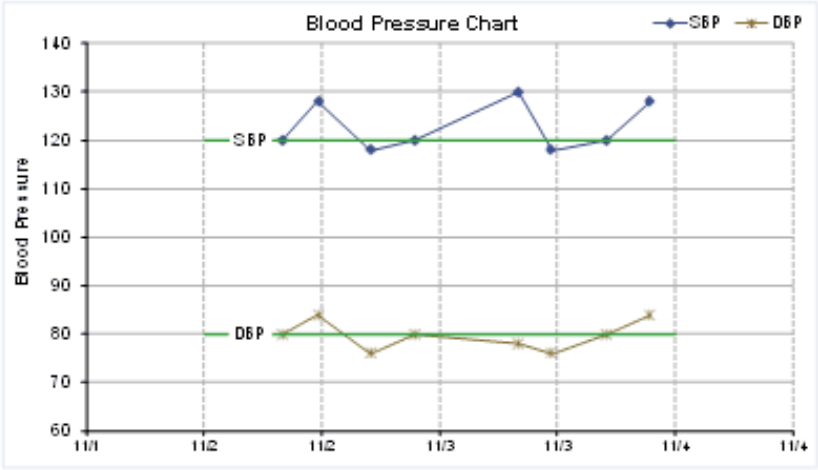
doi: 10.1097/HJH.0000000000002843

Form for reporting 7-day HBPM.

Blood Pressure Chart

http://www.vertex42.com/ExcelTemplates/blood-pressure-chart.html

	Target BP
Systolic (SBP)	120.00
Diastolic (DBP)	80.00



Date	Time	SBP	DBP	Notes
11/2/09	8:00 AM	120	80	Before blood pressure medication
11/2/09	11:30 AM	128	84	Walked one mile
11/2/09	5:00 PM	118	76	
11/2/09	9:30 PM	120	80	
11/3/09	8:00 AM	130	78	Feeling a little stressed
11/3/09	11:30 AM	118	76	
11/3/09	5:00 PM	120	80	
11/3/09	9:30 PM	128	84	Took a walk in the afternoon

Name _____

Day #	Date	Time	3 Morning Readings - First Thing in Morning 1-2 Minutes Apart				Time	3 Evening Readings - Before Bed 1-2 Minutes Apart		
Example	12/12/2012	6:30 AM	125/83	125/83	125/83		10:00 PM	128/85	128/85	128/85
1			/	/	/			/	/	/
2			/	/	/			/	/	/
3			/	/	/			/	/	/
4			/	/	/			/	/	/
5			/	/	/			/	/	/
6			/	/	/			/	/	/
7			/	/	/			/	/	/

Average Systolic Reading = Add up Days 2-7 Systolic readings (all 36 of them) and Divide by 36 = _____ = **Average Systolic Reading**

Average Diastolic Reading = Add up Days 2-7 Diastolic readings (all 36 of them) and Divide by 36 = _____ = **Average Diastolic Reading**

Blood Pressure Log

vertex42

	SBP	DBP
*Target:		

Date	Time	SBP	DBP	Notes

*Consult your doctor to determine your target blood pressure

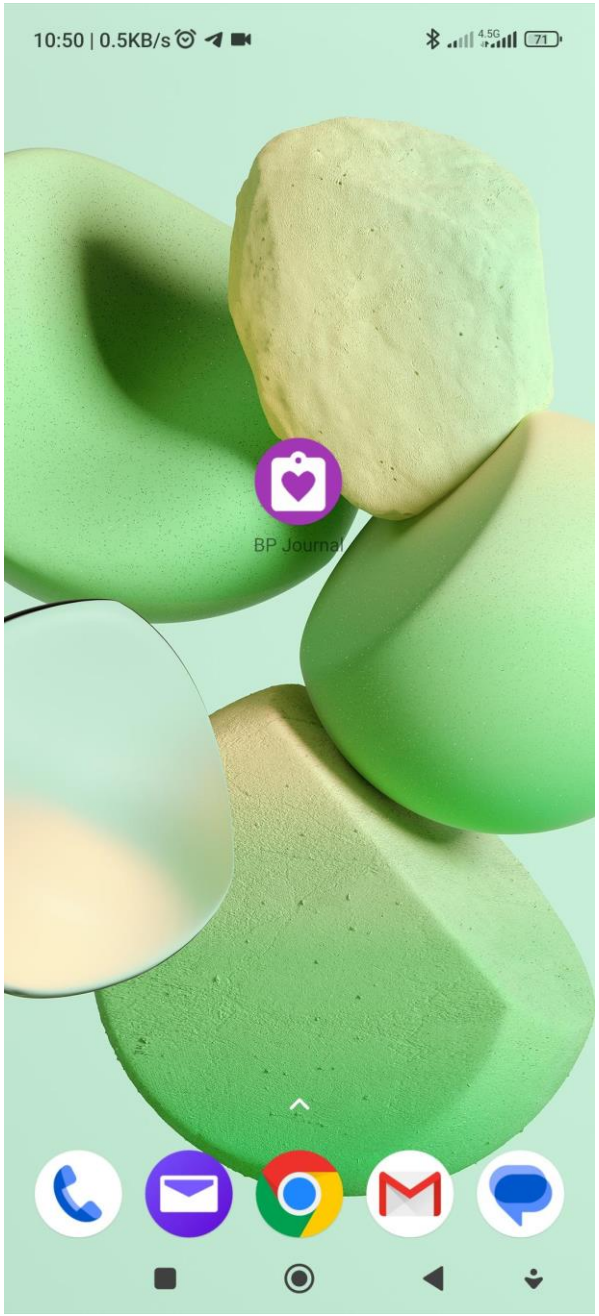
Blood Pressure Log

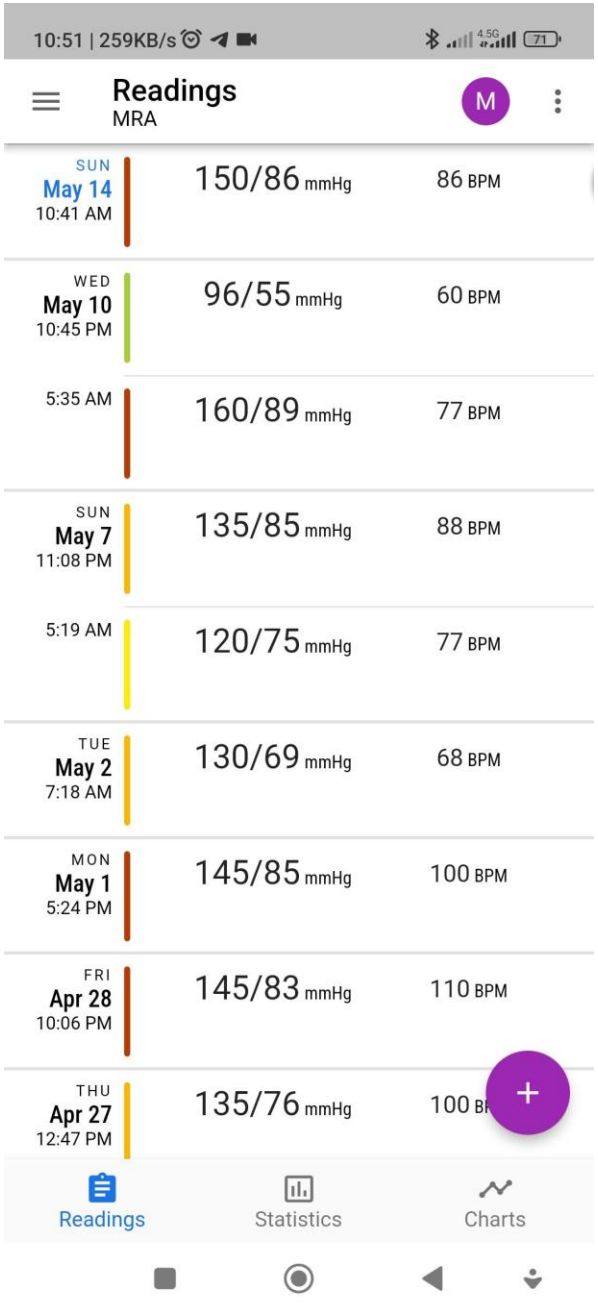
vertex42

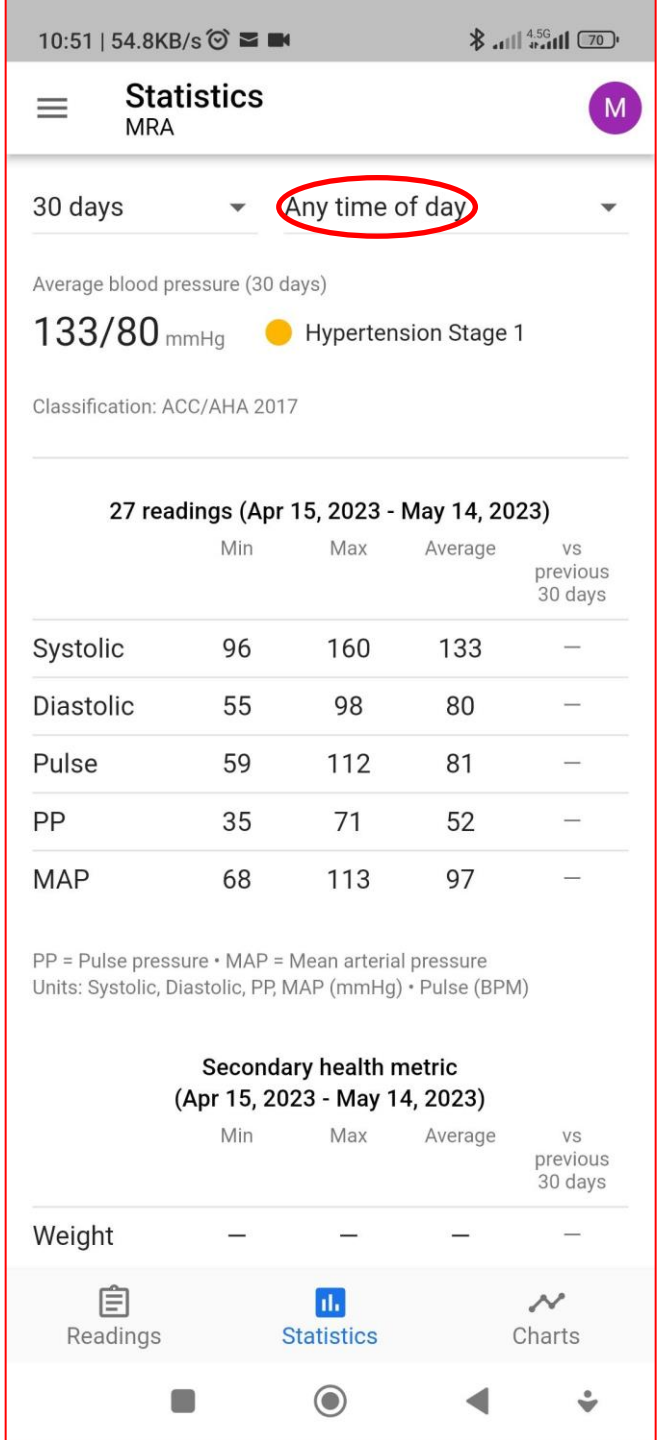
	SBP	DBP
*Target:		

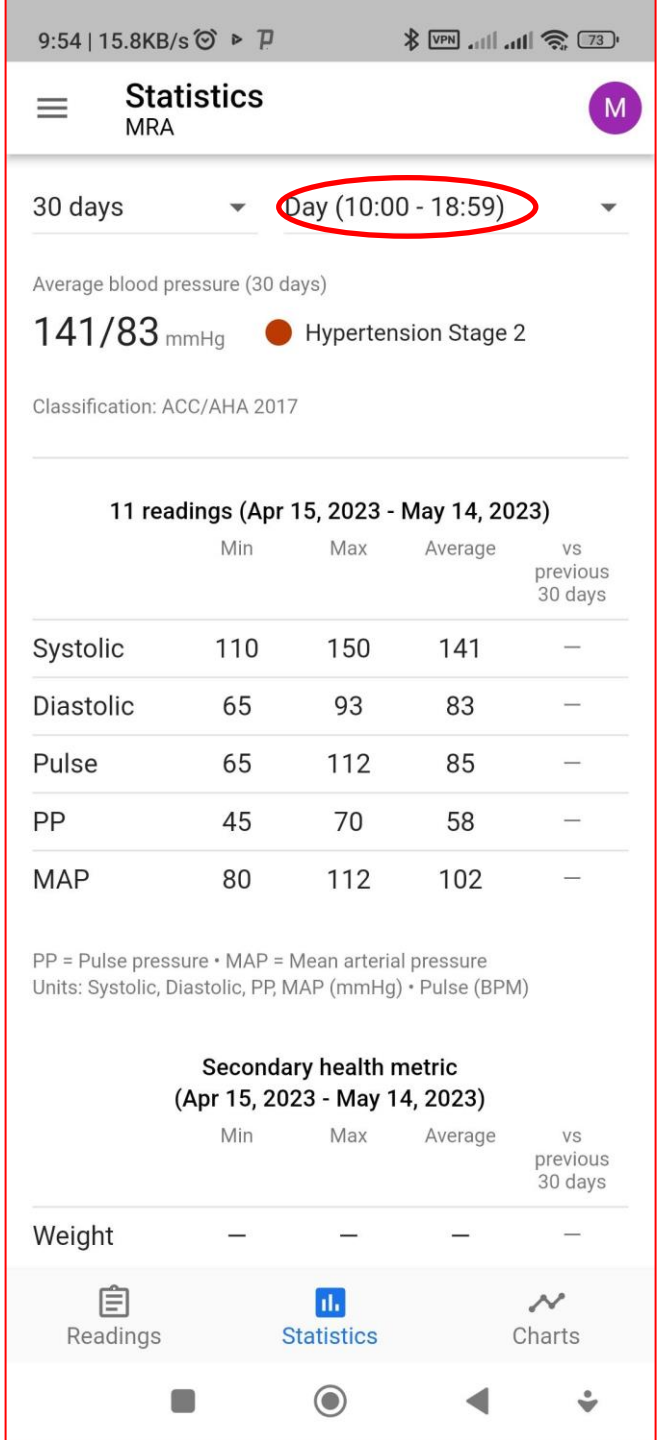
Date	Time	SBP	DBP	Notes

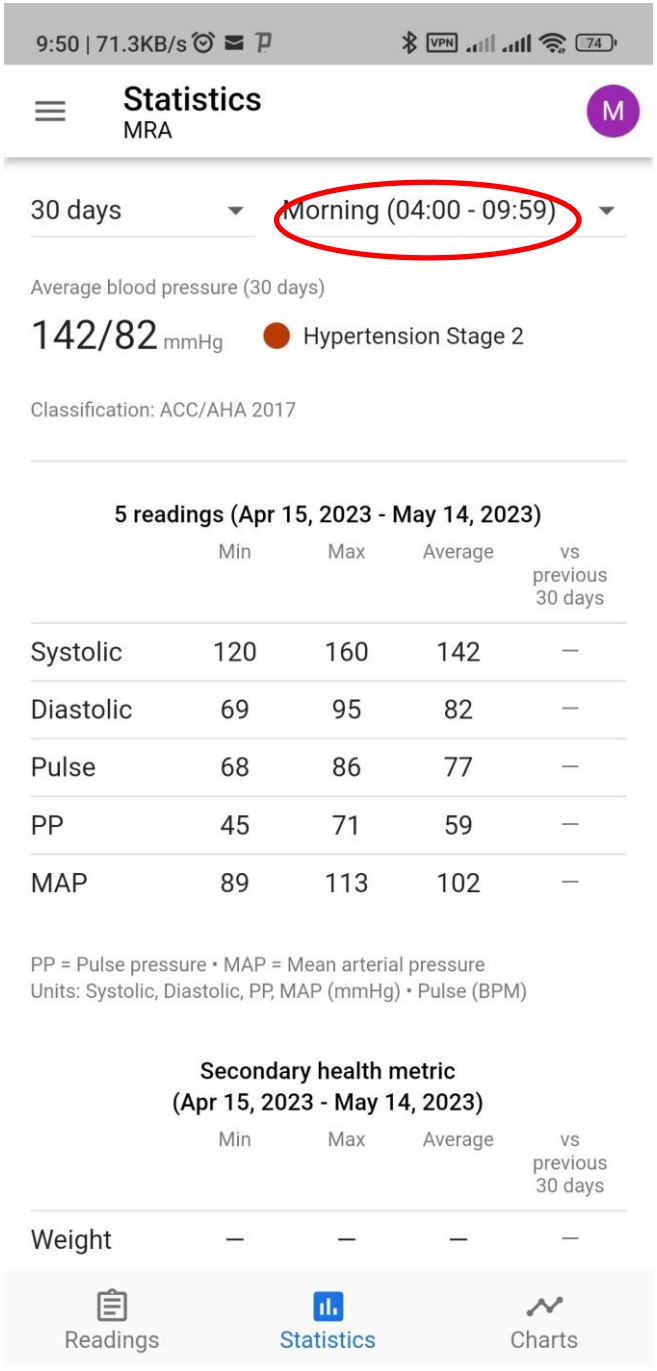
*Consult your doctor to determine your target blood pressure

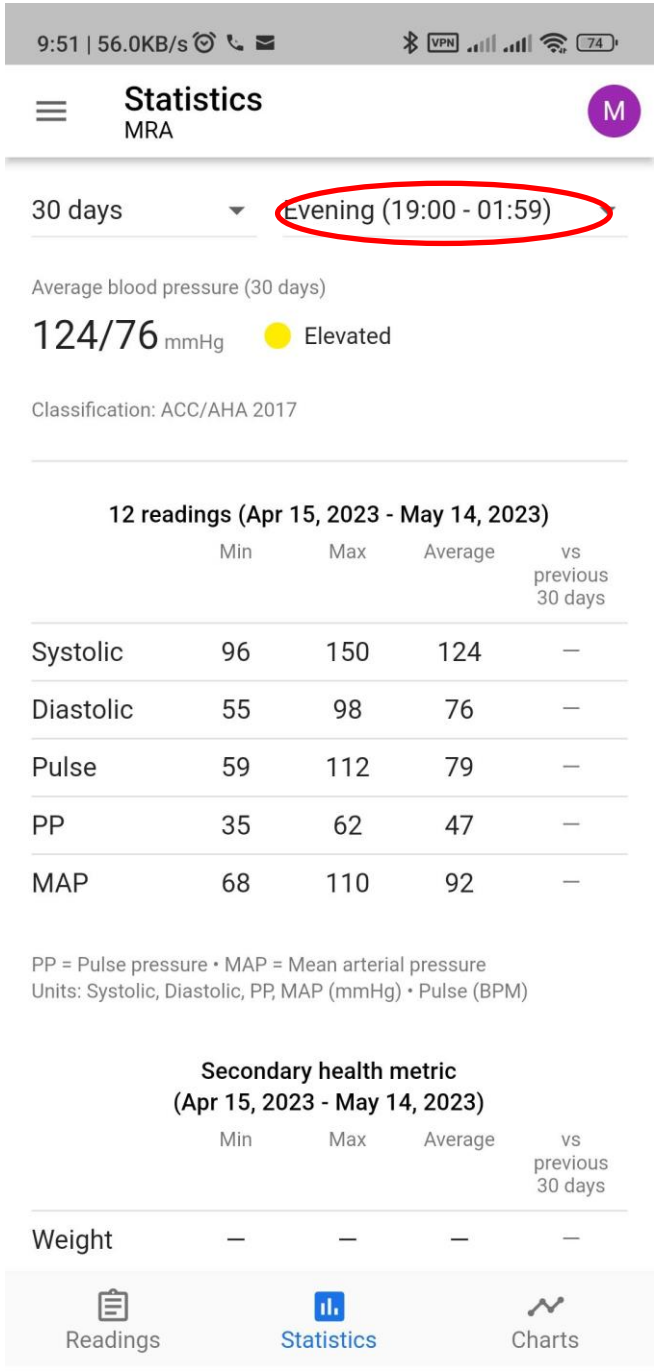

10:50 | 0.5KB/s
BP Journal

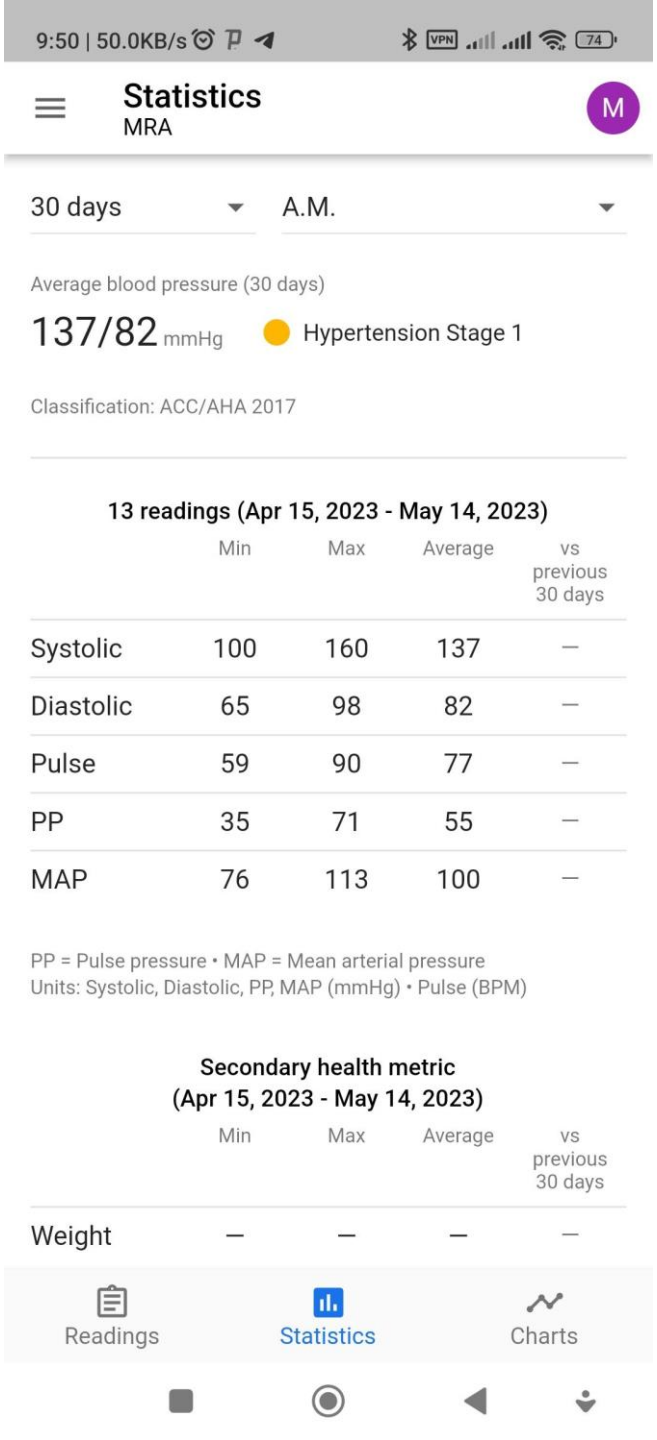

10:51 | 259KB/s
Readings
MRA
M
SUN
May 14
10:41 AM
150/86 mmHg
86 BPM
WED
May 10
10:45 PM
96/55 mmHg
60 BPM
5:35 AM
160/89 mmHg
77 BPM
SUN
May 7
11:08 PM
135/85 mmHg
88 BPM
5:19 AM
120/75 mmHg
77 BPM
TUE
May 2
7:18 AM
130/69 mmHg
68 BPM
MON
May 1
5:24 PM
145/85 mmHg
100 BPM
FRI
Apr 28
10:06 PM
145/83 mmHg
110 BPM
THU
Apr 27
12:47 PM
135/76 mmHg
Readings
Statistics
Charts

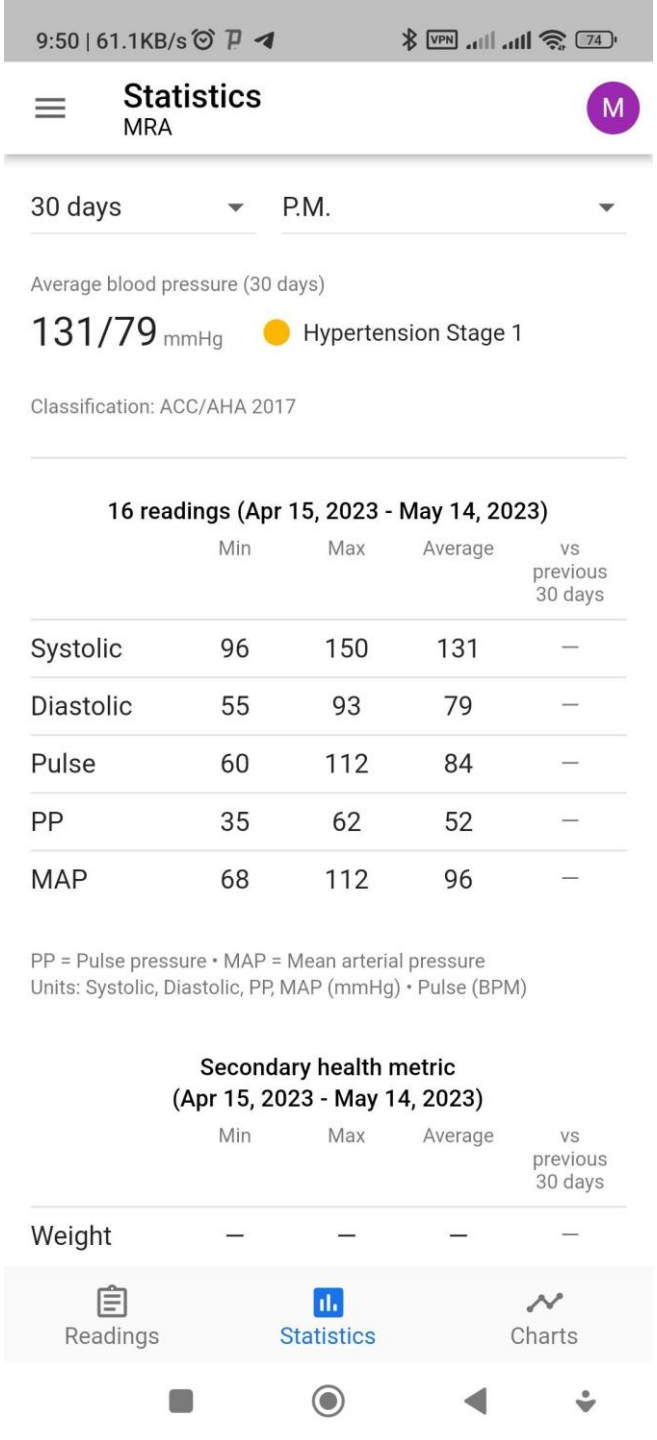

10:51 | 54.8KB/s
Statistics
MRA
M
30 days
Any time of day
Average blood pressure (30 days)
133/80 mmHg
Hypertension Stage 1
Classification: ACC/AHA 2017
27 readings (Apr 15, 2023 - May 14, 2023)
Min Max Average vs previous 30 days
Systolic 96 160 133 –
Diastolic 55 98 80 –
Pulse 59 112 81 –
PP 35 71 52 –
MAP 68 113 97 –
PP = Pulse pressure • MAP = Mean arterial pressure
Units: Systolic, Diastolic, PP, MAP (mmHg) • Pulse (BPM)
Secondary health metric
(Apr 15, 2023 - May 14, 2023)
Min Max Average vs previous 30 days
Weight – – – –
Readings
Statistics
Charts

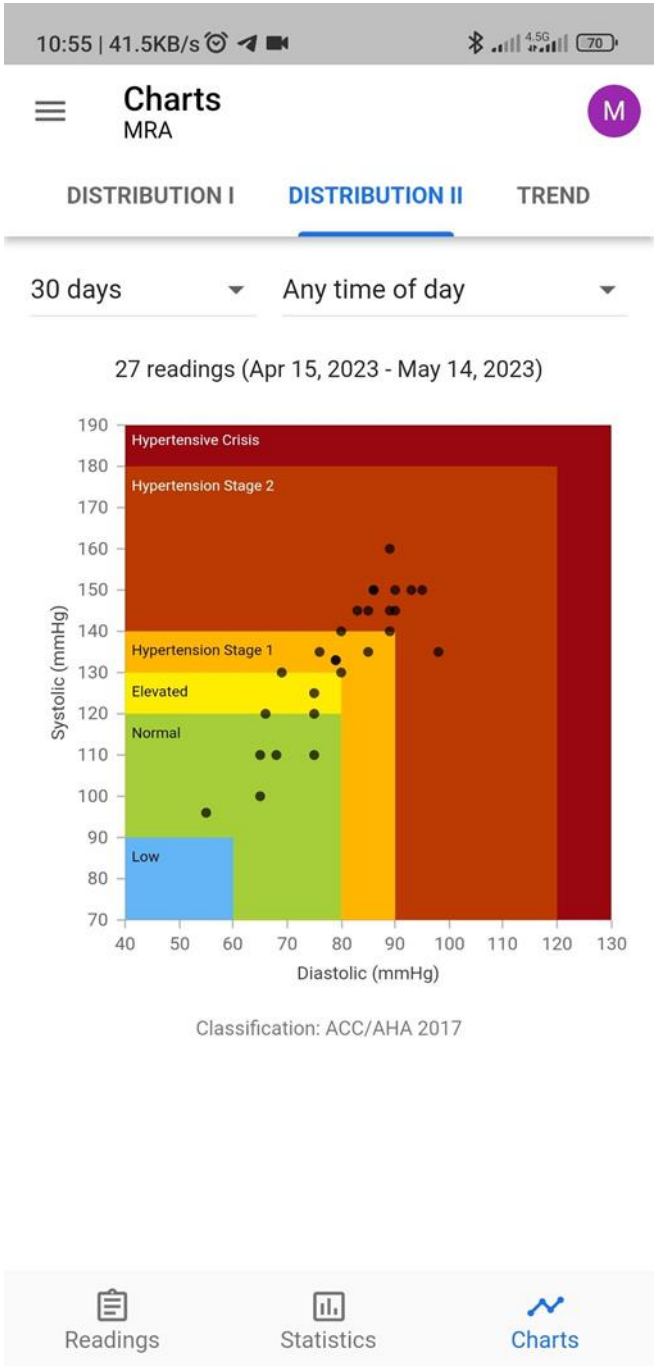

9:54 | 15.8KB/s
Statistics
MRA
M
30 days
Day (10:00 - 18:59)
Average blood pressure (30 days)
141/83 mmHg
Hypertension Stage 2
Classification: ACC/AHA 2017
11 readings (Apr 15, 2023 - May 14, 2023)
Min Max Average vs previous 30 days
Systolic 110 150 141 –
Diastolic 65 93 83 –
Pulse 65 112 85 –
PP 45 70 58 –
MAP 80 112 102 –
PP = Pulse pressure • MAP = Mean arterial pressure
Units: Systolic, Diastolic, PP, MAP (mmHg) • Pulse (BPM)
Secondary health metric
(Apr 15, 2023 - May 14, 2023)
Min Max Average vs previous 30 days
Weight – – – –
Readings
Statistics
Charts


9:50 | 71.3KB/s
Statistics
MRA
M
30 days
Morning (04:00 - 09:59)
Average blood pressure (30 days)
142/82 mmHg
Hypertension Stage 2
Classification: ACC/AHA 2017
5 readings (Apr 15, 2023 - May 14, 2023)
Min Max Average vs previous 30 days
Systolic 120 160 142 –
Diastolic 69 95 82 –
Pulse 68 86 77 –
PP 45 71 59 –
MAP 89 113 102 –
PP = Pulse pressure • MAP = Mean arterial pressure
Units: Systolic, Diastolic, PP, MAP (mmHg) • Pulse (BPM)
Secondary health metric
(Apr 15, 2023 - May 14, 2023)
Min Max Average vs previous 30 days
Weight – – – –
Readings
Statistics
Charts


9:51 | 56.0KB/s
Statistics
MRA
M
30 days
Evening (19:00 - 01:59)
Average blood pressure (30 days)
124/76 mmHg
Elevated
Classification: ACC/AHA 2017
12 readings (Apr 15, 2023 - May 14, 2023)
Min Max Average vs previous 30 days
Systolic 96 150 124 –
Diastolic 55 98 76 –
Pulse 59 112 79 –
PP 35 62 47 –
MAP 68 110 92 –
PP = Pulse pressure • MAP = Mean arterial pressure
Units: Systolic, Diastolic, PP, MAP (mmHg) • Pulse (BPM)
Secondary health metric
(Apr 15, 2023 - May 14, 2023)
Min Max Average vs previous 30 days
Weight – – – –
Readings
Statistics
Charts


9:50 | 50.0KB/s
Statistics
MRA
M
30 days
A.M.
Average blood pressure (30 days)
137/82 mmHg
Hypertension Stage 1
Classification: ACC/AHA 2017
13 readings (Apr 15, 2023 - May 14, 2023)
Min Max Average vs previous 30 days
Systolic 100 160 137 –
Diastolic 65 98 82 –
Pulse 59 90 77 –
PP 35 71 55 –
MAP 76 113 100 –
PP = Pulse pressure • MAP = Mean arterial pressure
Units: Systolic, Diastolic, PP, MAP (mmHg) • Pulse (BPM)
Secondary health metric
(Apr 15, 2023 - May 14, 2023)
Min Max Average vs previous 30 days
Weight – – – –
Readings
Statistics
Charts


9:50 | 61.1KB/s
Statistics
MRA
M
30 days
P.M.
Average blood pressure (30 days)
131/79 mmHg
Hypertension Stage 1
Classification: ACC/AHA 2017
16 readings (Apr 15, 2023 - May 14, 2023)
Min Max Average vs previous 30 days
Systolic 96 150 131 –
Diastolic 55 93 79 –
Pulse 60 112 84 –
PP 35 62 52 –
MAP 68 112 96 –
PP = Pulse pressure • MAP = Mean arterial pressure
Units: Systolic, Diastolic, PP, MAP (mmHg) • Pulse (BPM)
Secondary health metric
(Apr 15, 2023 - May 14, 2023)
Min Max Average vs previous 30 days
Weight – – – –
Readings
Statistics
Charts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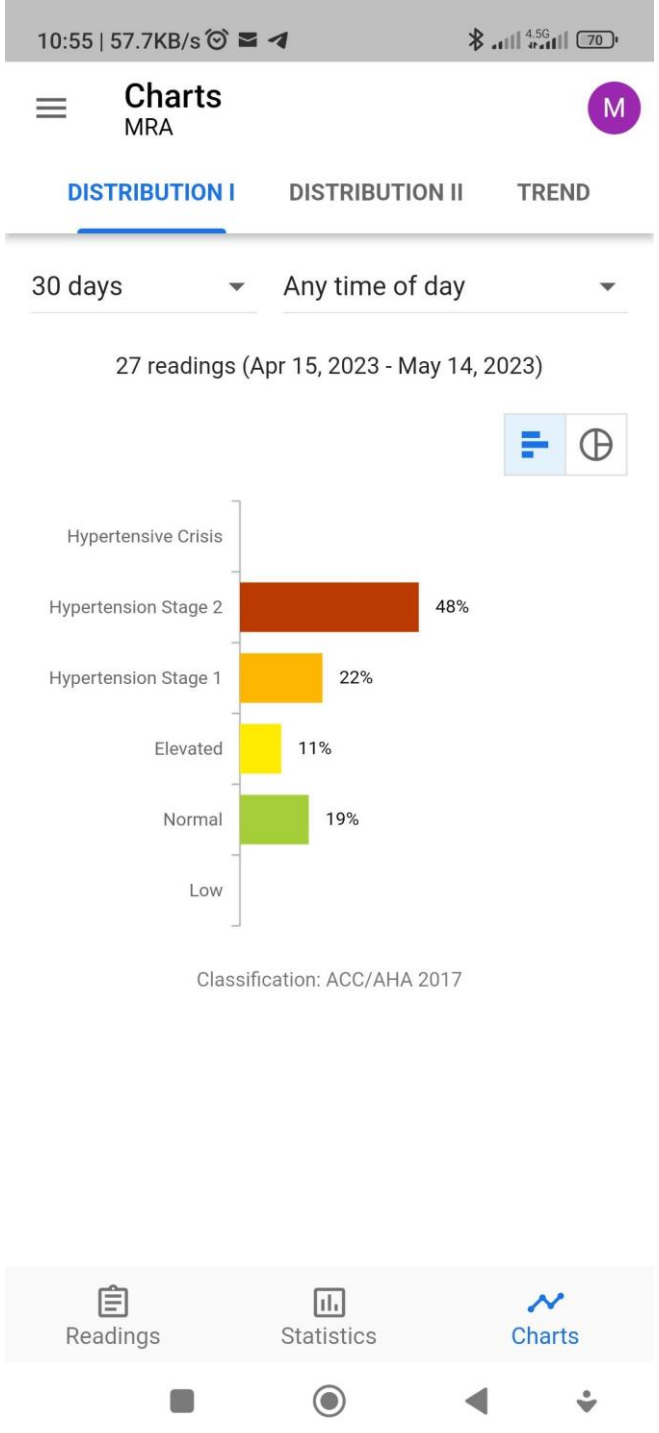
Charts
MRA
M
DISTRIBUTION I
DISTRIBUTION II
TREND
30 days
Any time of day
27 readings (Apr 15, 2023 - May 14, 2023)
Hypertensive Crisis
Hypertension Stage 2
Hypertension Stage 1
Elevated
Normal
Low
Systolic (mmHg)
Diastolic (mmHg)
Classification: ACC/AHA 2017
Readings
Statistics
Charts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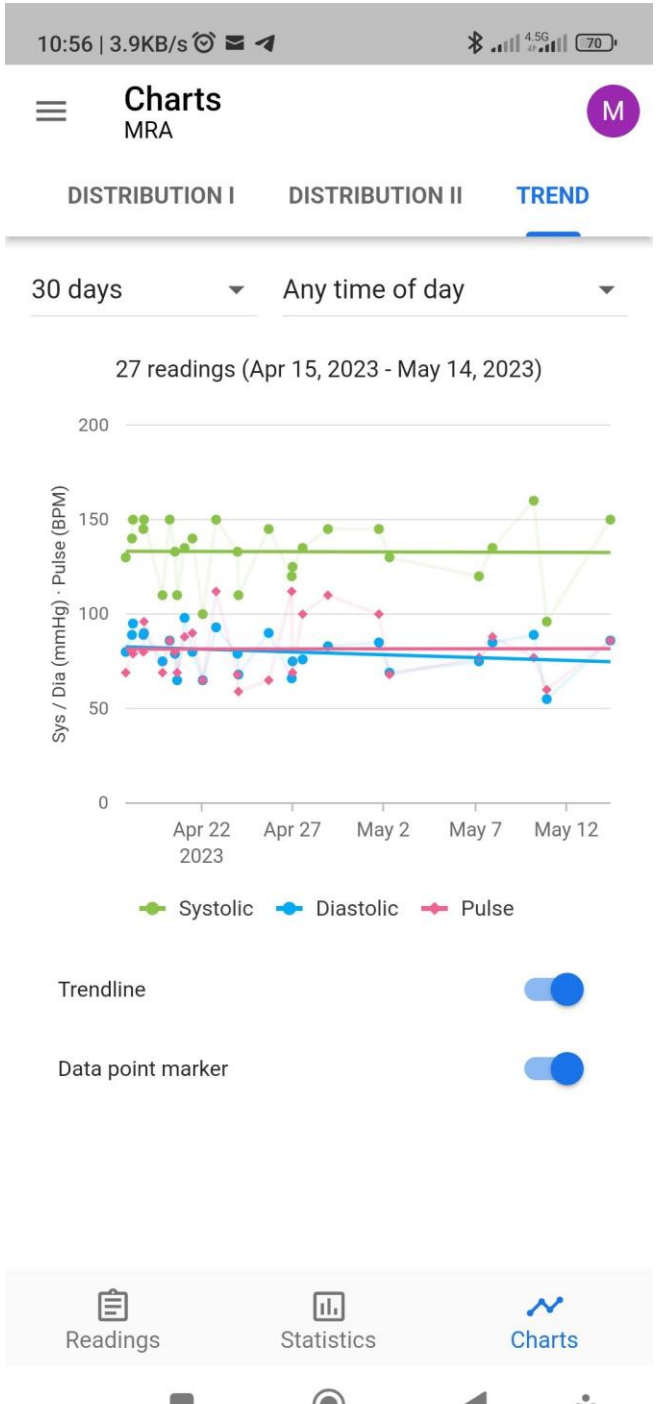
Charts
MRA
M
DISTRIBUTION I
DISTRIBUTION II
TREND
30 days
Any time of day
27 readings (Apr 15, 2023 - May 14, 2023)
Hypertensive Crisis
Hypertension Stage 2
48%
Hypertension Stage 1
22%
Elevated
11%
Normal
19%
Low
Classification: ACC/AHA 2017
Readings
Statistics
Charts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Charts
MRA
M
DISTRIBUTION I
DISTRIBUTION II
TREND
30 days
Any time of day
27 readings (Apr 15, 2023 - May 14, 2023)
200
150
100
50
0
Sys / Dia (mmHg) · Pulse (BPM)
Apr 22
2023
Apr 27
May 2
May 7
May 12
Systolic
Diastolic
Pulse
Trendline
Data point marker
Readings
Statistics
Charts

Today

Blood Pressure Report

Name: MRA
Gender: Male
Age: 56
Date range: Apr 17, 2023 - May 14, 2023
Total readings: 27

Date	Time	Systolic (mmHg)	Diastolic (mmHg)	Pulse (BPM)	Irregular heartbeat (Y/N)	Pulse pressure (mmHg)	Mean arterial pressure (mmHg)	BP category & Note
Sun, May 14, 2023	10:41 AM	**150**	**86**	86	N	**64**	107	Hypertension Stage 2 Left arm, Seated

PDF

MRA_20230417_20230514.pdf

5 pages • 355 kB • PDF

11:31 ✓

Blood Pressure Report

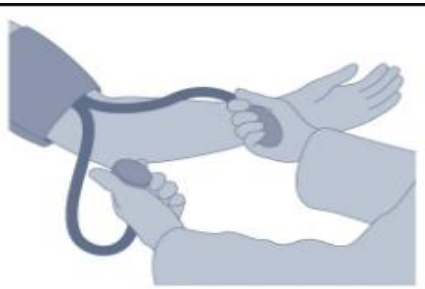
Name: MRA
Gender: Male
Age: 56

Date range: Apr 15, 2023 - May 14, 2023
Total readings: 27

Date	Time	Systolic (mmHg)	Diastolic (mmHg)	Pulse (BPM)	Irregular heartbeat (Y/N)	Pulse pressure (mmHg)	Mean arterial pressure (mmHg)	BP category & Note
Sun, May 14, 2023	10:41 AM	**150**	**86**	86	N	**64**	107	Hypertension Stage 2 Left arm, Seated
Wed, May 10, 2023	10:45 PM	96	55	60	N	41	**68**	Normal Left arm, Seated
Wed, May 10, 2023	5:35 AM	**160**	**89**	77	N	**71**	**112**	Hypertension Stage 2 Left arm, Seated
Sun, May 7, 2023	11:08 PM	**135**	**85**	88	N	50	101	Hypertension Stage 1 Left arm, Seated
Sun, May 7, 2023	5:19 AM	120	75	77	N	45	90	Elevated Left arm, Seated
Tue, May 2, 2023	7:18 AM	**130**	69	68	N	**61**	89	Hypertension Stage 1 Left arm, Seated
Mon, May 1, 2023	5:24 PM	**145**	**85**	100	N	60	105	Hypertension Stage 2 Left arm, Seated
Fri, Apr 28, 2023	10:06 PM	**145**	**83**	**110**	N	**62**	103	Hypertension Stage 2 Left arm, Seated

	HBP	OBP	ABP
Reproducibility, study power, and sample size	+++	+	+++
Exclusion of white coat hypertension	+++	–	+++
Observer bias elimination	+++ (automated devices or tele-monitoring)	+	+++
Placebo effect elimination	+++	–	+++
Assessment of magnitude of BP changes	+++	+	+++
Assessment of duration of antihypertensive drug action	++	+	+++
Time-course of BP lowering effect (days)	++	+	–
Assessment of homogeneity of antihypertensive drug action (smoothness index)	–	–	+++
Assessment of morning hypertension	+++	+	+++
Assessment of nocturnal hypertension—detection of non-dippers	++ (devices which monitor asleep BP)	–	+++
Identification of masked uncontrolled hypertension	+++	–	+++
Diagnosis of true resistant hypertension	++	+	+++
Assessment of short-term variability	–	–	++
Assessment of mid-term variability	++	–	–
Assessment of long-term variability	++	++	+
Association with preclinical organ damage	+++	+	+++
Assessment of arterial stiffness	–	–	++ (AASI
Assessment of treatment-induced changes in organ damage	++	+	+++
Association with cardiovascular events risk	+++	+	+++
Compliance with drug treatment	+++	+	+
Patients' preference	+++	+	+
Repeated monitoring in longitudinal trials	+++	++	+
Cost	+++	++	+

BP blood pressure, *HBP* home BP, *OBP* office BP, *ABP* ambulatory BP,



Static measurement → **Daily activities and sleep** → **Dynamic conditions**

Office BP measurement	Home BP monitoring	Ambulatory BP monitoring	Cuffless wearable BP monitors
• Strong evidence • Readily available • Often not standardized • Poor reproducibility • Subject to white-coat and masked hypertension effects	• Widely available • Acceptable by users • Best method for long-term follow-up of treated patients • Requires training and medical supervision • Variable accuracy of devices available on the market • Possible misreporting of readings by users	• Multiple readings over 24 h • Measures BP levels during daily activities and sleep • Best method for hypertension diagnosis • Not widely available • Not accepted by all users, particularly for repeated use	• Great potential for BP screening, monitoring and management • Can provide multiple readings over long periods of time • No cuff-induced discomfort • Questionable accuracy • Unproven clinical usefulness
BP variability • Long-term • Visit-to-visit	**BP variability** • Mid-term • Day-to-day	**BP variability** • Short-term • Hour-to-hour	**BP variability** • Very short-term, short-term, mid-term and long-term • Beat-to-beat, hour-to-hour, day-to-day, week-to-week and

Consensus Document

Cuffless blood pressure measuring devices: review and statement by the European Society of Hypertension Working Group on Blood Pressure Monitoring and Cardiovascular Variability

George S. Stergiou[a], Ramakrishna Mukkamala[b], Alberto Avolio[c], Konstantinos G. Kyriakoulis[a], Stephan Mieke[d], Alan Murray[e], Gianfranco Parati[f,g], Aletta E. Schutte[h], James E. Sharman[i], Roland Asmar[j], Richard J. McManus[k], Kei Asayama[l], Alejandro De La Sierra[m], Geoffrey Head[n], Kazuomi Kario[o], Anastasios Kollias[a], Martin Myers[p], Teemu Niiranen[q,r], Takayoshi Ohkubo[l], Jiguang Wang[s], Gregoire Wuerzner[t], Eoin O'Brien[u], Reinhold Kreutz[v], and Paolo Palatini[w], on behalf of the European Society of Hypertension Working Group on Blood Pressure Monitoring and Cardiovascular Variability

Background: Many cuffless blood pressure (BP) measuring devices are currently on the market claiming that they provide accurate BP measurements. These technologies have considerable potential to improve the awareness, treatment, and management of hypertension. However, recent guidelines by the European Society of Hypertension do not recommend cuffless devices for the diagnosis and management of hypertension.

Objective: This statement by the European Society of ...

Keywords: accuracy, calibration, continuous, cuffless blood pressure measurement, cuffless blood pressure monitoring, photoplethysmography, smartwatch, technology, validation, wearable

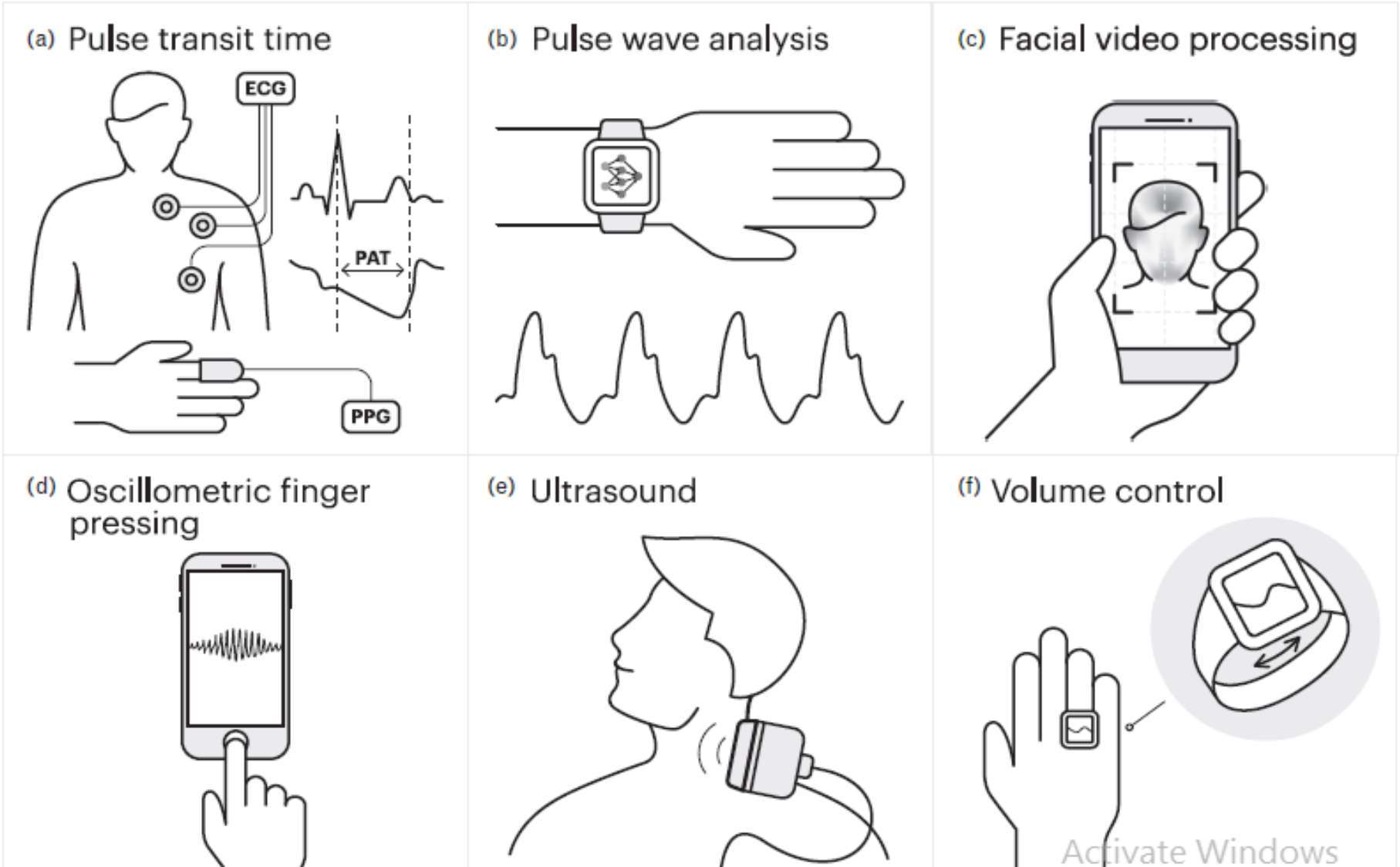
Journal of Hypertension 2022, 40:1449–1460

[a]Hypertension Center STRIDE-7, National and Kapodistrian University of Athens

TABLE 1. Summary of cuffless blood pressure technologies

Category	Method	Advantages		Disadvantages		Evidence
Requiring user cuff calibration (*Estimate BP changes*)	PTT (a)	Continuous; without user action; not disturbing	Supporting theory	Calibration via periodic cuff BP measurement or by demographic data input	Two measurements sites	Many published studies
	PWA (b)		Single sensor		Little theory (may not work well in many individuals)	Regulatory-approved, cuff-calibrated, contact monitors
	Facial video processing (c)		Widely available device (smartphone)		Insufficient waveform Quality	Little published data on intra-individual BP change tracking
Not requiring user cuff calibration (*Estimate BP values*)	Oscillometric finger pressing (d)	Calibration not needed; solid theory (could work in many individuals)	Potential widely available device (smartphone)	User action		Few published studies
	Ultrasound (e)		Central PP measurement	Difficult probe placement (operator required)		
	Volume control (f)		Continuous	Disturbing (finger numbness)		

Cuffless BP devices should not be used for the evaluation or management of hypertension in clinical practice.



2020 International Society of Hypertension Global Hypertension Practice Guidelines

Thomas Unger, Claudio Borghi, Fadi Charchar, Nadia A. Khan, Neil R. Poulter, Dorairaj Prabhakaran, Agustin Ramirez, Markus Schlaich, George S. Stergiou, Maciej Tomaszewski, Richard D. Wainford, Bryan Williams, Aletta E. Schutte

Table of Contents

Section 1: Introduction

Context and Purpose of This Guideline

Statement of Remit

To align with its mission to reduce the global burden of raised blood pressure (BP), the International Society of Hypertension (ISH) has developed worldwide practice guidelines for the management of hypertension in adults, aged 18 years and older.

The ISH Guidelines Committee extracted evidence-based content presented in recently published extensively reviewed guidelines and tailored ESSENTIAL and OPTIMAL standards of care in a practical format that is easy-to-use particularly in low, but also in high resource settings – by clinicians, but also nurses and community health workers, as appropriate. Although distinction between low and high resource settings often refers to high (HIC) and low- and middle-income countries (LMIC), it is well established that in HIC there are areas with low resource settings, and vice versa.

Herein optimal care refers to evidence-based standard of care articulated in recent guidelines[1,2] and summarized here, whereas ESSENTIAL standards recognize that OPTIMAL standards would not always be possible. Hence essential standards refer to minimum standards of care. To allow specification of essential standards of care for low resource settings, the Committee was often confronted with the limitation or absence in clinical evidence, and thus applied expert opinion.

Classification of Hypertension Based on Office Blood Pressure Current Guidelines

Categories			Systolic, mm Hg		Diastolic, mm Hg
ESC/ESH 2018*	ISH 2020†	ACC/AHA 2017‡			
Normal	Normal	Elevated	120–129	and/or	80–84
High normal	High normal	Stage 1 hypertension	130–139	and/or	85–89
Grade 1 hypertension	Grade 1 hypertension	Stage 2 hypertension	140–159	and/or	90–99
Grade 2 hypertension	Grade 2 hypertension		160–179	and/or	100–109
Grade 3 hypertension			≥180	and/or	≥110

ACC indicates American College of Cardiology; AHA, American Heart Association; ESC, European Society of Cardiology; ESH, European Society of Hypertension and ISH, International Society of Hypertension.

* Williams et al.[1]

† Unger et al.[5]

‡ Whelton et al.[3]

Corresponding values of SBP/DBP for clinic, HBPM, daytime, nighttime, and 24-hour ABPM measurements

Corresponding values of SBP/DBP for clinic, HBPM, daytime, nighttime, and 24-hour ABPM measurements

Clinic	HBPM	Daytime ABPM	Nighttime ABPM	24-hour ABPM
120/80	120/80	120/80	100/65	115/75
130/80	130/80	130/80	110/65	125/75
140/90	135/85	135/85	120/70	130/80
160/100	145/90	145/90	140/85	145/90

SBP: systolic blood pressure; DBP: diastolic blood pressure; HBPM: home blood pressure monitoring; ABPM: ambulatory blood pressure monitoring.

References:

1. *Uhlig K, Balk EM, Patel K, et al. Self-Measured Blood Pressure Monitoring: Comparative Effectiveness. Agency for Healthcare Research and Quality, Rockville, MD 2012.*
2. *Margolis KL, Asche SE, Bergdall AR, et al. Effect of home blood pressure telemonitoring and pharmacist management on blood pressure control: a cluster randomized clinical trial. JAMA 2013; 310:46.*
3. *McManus RJ, Mant J, Haque MS, et al. Effect of self-monitoring and medication self-titration on systolic blood pressure in hypertensive patients at high risk of cardiovascular disease: the TASMIN-SR*

Goal blood pressure thresholds from different society guidelines according to underlying comorbidity

Goal blood pressure thresholds from different society guidelines according to underlying comorbidity

Underlying comorbidity	ACC/AHA [1]	ESC/ESH [2]	CHEP [3]	NHFA [4]	JHS [5]	NICE [6]	ACP/AAFP [7]	ADA [8]	KDIGO [9]
Established atherosclerotic cardiovascular disease*	<130/80	<130/80	<120/80	<120/80	<130/80	<140/90			
Heart failure	<130/80	<130/80	<120/80	<120/80	<130/80	<140/90			
Diabetes mellitus	<130/80	<130/80	<130/80	<120/80	<130/80	<140/90		<140/90¶	
Chronic kidney disease	<130/80	<130/80	<120/80	<120/80	<130/80	<140/90			<120/80
High cardiovascular risk△	<130/80	<130/80	<120/80	<120/80	<130/80	<140/90			
Older adults◇	<130/80	<130/80	<120/80	<120/80	<140/90	<140/90	<150/90§		
No comorbidity	<130/80	<130/80	<140/90	<140/90	<130/80	<140/90			

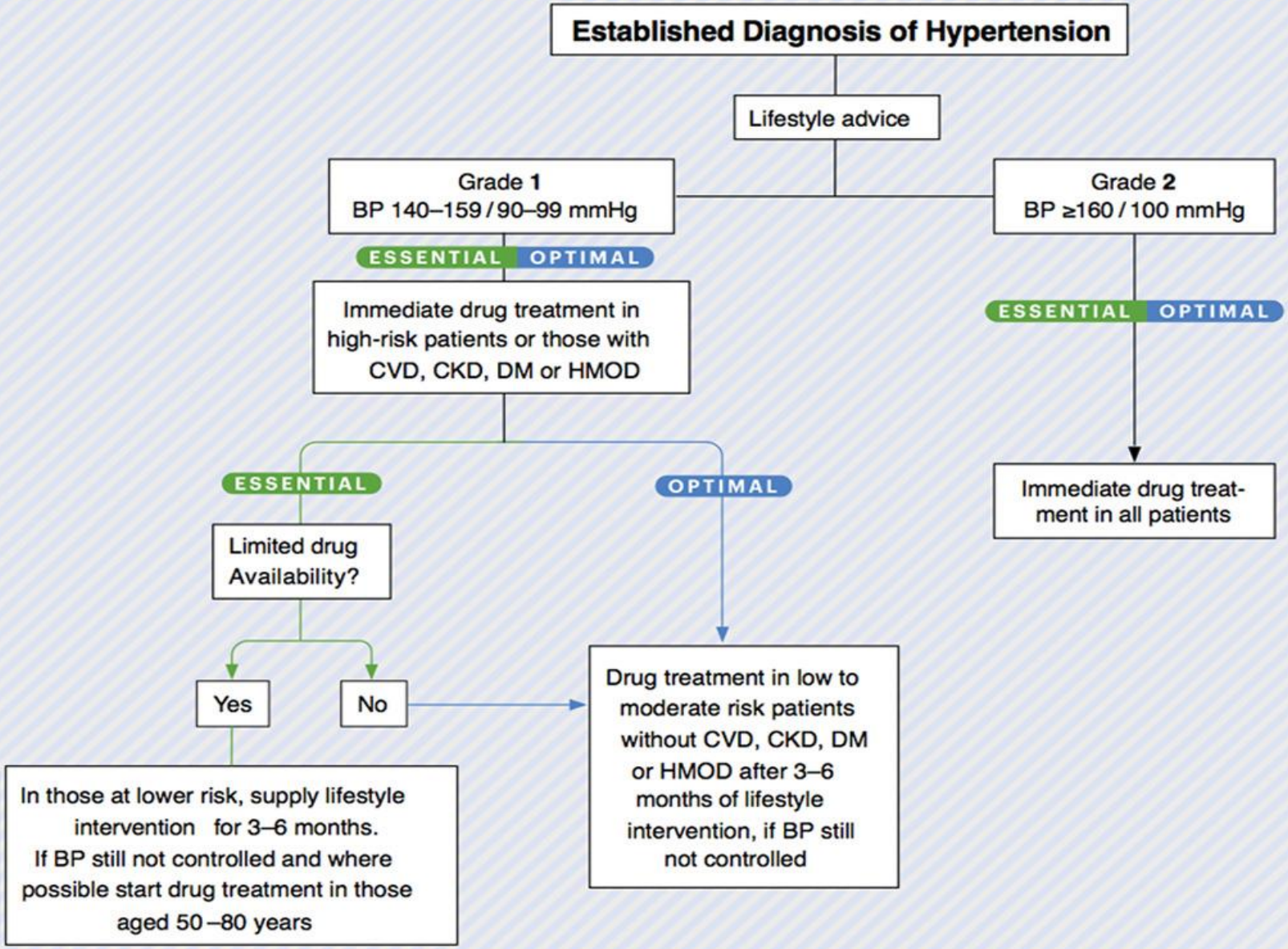
All targets listed are predicated on therapy being well tolerated. (In general, if a patient cannot tolerate the target blood pressure, then the target must be adjusted upward.)
All values are in mmHg. All targets assume that blood pressure is monitored optimally (eg, with standardized office measurement, automated oscillometric blood pressure monitoring).

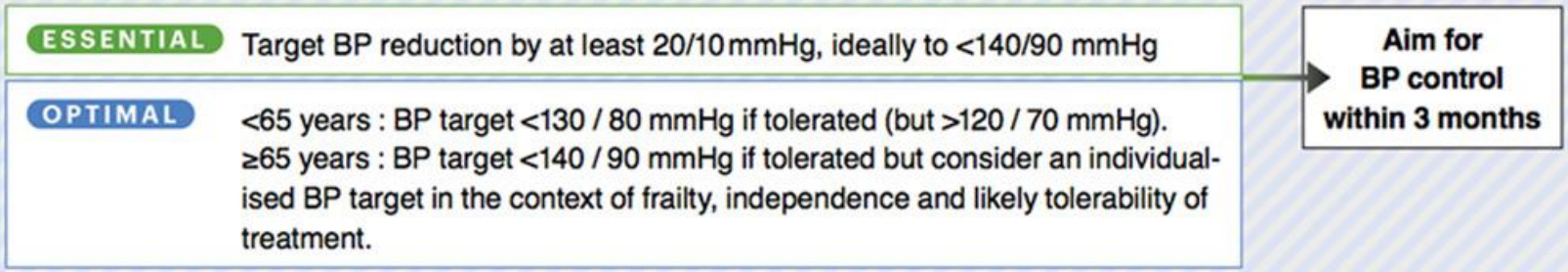
Goal blood pressure according to baseline risk for cardiovascular disease and method of measuring blood pressure

Goal blood pressure according to baseline risk for cardiovascular disease and method of measuring blood pressure

	Routine/conventional office blood pressure (manual measurement with stethoscope or oscillometric device)*	Unattended AOBPM, daytime ABPM, or home blood pressure ¶
Higher-risk population Δ		
▪ Known ASCVD ◇ ▪ Heart failure ▪ Diabetes mellitus ▪ Chronic kidney disease ▪ Age ≥65 years § ▪ Calculated 10-year risk of ASCVD event ≥10% ¥	125 to 130/<80	120 to 125/<80
Lower-risk ‡		
▪ None of the above risk factors	130 to 139/<90	125 to 135/<90

- All target ranges presented above are in mmHg.
- On average, blood pressure readings are 5 to 10 mmHg lower with digital, unattended, or out-of-office methods of measurement (ie, AOBPM, daytime ABPM, home blood pressure) than with routine/standard methods of office measurement (ie, manual auscultatory or oscillometric measurement), presumably due to the "white coat effect." However, it is critical to realize


Established Diagnosis of Hypertension
Lifestyle advice
Grade 1
BP 140–159 / 90–99 mmHg
Grade 2
BP ≥160 / 100 mmHg
ESSENTIAL
OPTIMAL
ESSENTIAL
OPTIMAL
Immediate drug treatment in high-risk patients or those with CVD, CKD, DM or HMOD
Immediate drug treatment in all patients
ESSENTIAL
OPTIMAL
Limited drug Availability?
Yes
No
Drug treatment in low to moderate risk patients without CVD, CKD, DM or HMOD after 3–6 months of lifestyle intervention, if BP still not controlled
In those at lower risk, supply lifestyle intervention for 3–6 months. If BP still not controlled and where possible start drug treatment in those aged 50–80 years


ESSENTIAL
Target BP reduction by at least 20/10 mmHg, ideally to <140/90 mmHg
OPTIMAL
<65 years : BP target <130 / 80 mmHg if tolerated (but >120 / 70 mmHg).
≥65 years : BP target <140 / 90 mmHg if tolerated but consider an individualised BP target in the context of frailty, independence and likely tolerability of treatment.
Aim for BP control within 3 months

ESSENTIAL

- Use whatever drugs are available with as many of the ideal characteristics (see ***Table 9***) as possible.
- Use free combinations if SPCs are not available or unaffordable
- Use thiazide diuretics if thiazide-like diuretics are not available
- Use alternative to DHP-CCBs if these are not available or not tolerated (i.e. Non-DHP-CCBs: diltiazem or verapamil).

OPTIMAL

Ideally Single Pill Combination Therapy (SPC)	**Step 1** Dual low-dose# combination	**A + C** [a, b, c]
	Step 2 Dual full-dose combination	**A + C** [a, b]
	Step 3 Triple combination	**A + C + D**
	Step 4 (Resistant Hypertension) Triple Combination + Spironolactone or other drug*	**A + C +D Add Spironolactone (12.5 – 50 mg o.d.)**[d]

ESSENTIAL OPTIMAL

Consider beta-blockers at any treatment step when there is a specific indication for their use, e.g. heart failure, angina, post-MI, atrial fibrillation, or younger women with, or planning pregnancy.

a) Consider monotherapy in low risk grade 1 hypertension or in very old (≥80 yrs) or frailer patients.
b) Consider A + D in post-stroke, very elderly, incipient HF or CCB intolerance.
c) Consider A + C or C + D in black patients.
d) Caution with spironolactone or other potassium sparing diuretics when estimated GFR <45 ml/min/1.73m² or K^+ >4.5 mmol/L.

A = ACE-Inhibitor or ARB (Angiotensin Receptor Blocker)
C = DHP-CCB (Dihydropyridine -Calcium Channel Blocker)
D = Thiazide-like diuretic
Supportive references: A + C,[69,70] Spironolactone,[71] Alpha-blocker,[72] C + D[73].

* Alternatives include: Amiloride, doxazosin, eplerenone, clonidine or beta-blocker.

low-dose generally refers to half of the maximum recommended dose

RCT-based benefits between ACE-I's and ARB's were not always identical in different patient populations. Choice between the two classes of RAS-Blockers will depend on patient characteristics, availability, costs and tolerability.

ESC European Society of Cardiology

European Heart Journal (2022) **43**, 3302–3311
https://doi.org/10.1093/eurheartj/ehac432

SPECIAL ARTICLE

Harmonization of the American College of Cardiology/American Heart Association and European Society of Cardiology/European Society of Hypertension Blood Pressure/ Hypertension Guidelines

Comparisons, Reflections, and Recommendations

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Received 20 July 2022; online publish-ahead-of-print 12 August 2022

Table 1 BP Measurement

American College of Cardiology/American Heart Association	European Society of Cardiology/European Society of Hypertension
Strong emphasis on measurement accuracy.	Strong emphasis on measurement accuracy.
Use of repeated office readings (≥2 readings on ≥2 occasions).	Use of repeated readings (3 readings, with additional readings when first 2 differ by ≥10 mm Hg or BP unstable because of an arrhythmia). BP is recorded as the average of the last 2 BP readings.
Confirmation of office hypertension by means of out-of-office (HBPM or ABPM) BP measurements.	Confirmation of hypertension by means of repeated office, or out-of-office (ABPM or HBPM) BP measurements.
Out-of-office measurements to recognize masked and white coat hypertension.	Out-of-office BP measurements to recognize masked and white coat hypertension.
	Heart rate should be also recorded during BP measurements.

Table 2 American College of Cardiology/American Heart Association Table of Blood Pressure Equivalence for Clinic and Out-of-Office Readings

Clinic	Home	Ambulatory blood pressure monitoring		
		Daytime	Nighttime	24 hours
120/80	120/80	120/80	100/65	115/75
130/80	130/80	130/80	110/65	125/75
140/90	135/85	135/85	120/70	130/80
160/100	145/90	145/90	140/85	145/90

Table 3 European Society of Cardiology/European Society of Hypertension Table of Out-of-Office Equivalence for an Office Systolic Blood Pressure/Diastolic Blood Pressure of 140/90 mm Hg

Office	Home	Ambulatory blood pressure monitoring		
		Daytime	Nighttime	24 hours
140/90	135/85	135/85	120/70	130/80

Table 4 Blood Pressure Classification

Categories	Systolic blood pressure, mm Hg	And/or	Diastolic blood pressure, mm Hg
American College of Cardiology/American Heart Association			
Normal	<120	and	<80
Elevated	120–129	and	<80
Hypertension, stage 1	130–139	or	80–89
Hypertension, stage 2	≥140	or	≥90
European Society of Cardiology/European Society of Hypertension			
Optimal	<120	and	<80
Normal	120–129	and/or	80–84
High normal	130–139	and/or	85–89
Hypertension, grade 1	140–159	and/or	90–99
Hypertension, grade 2	160–179	and/or	100–109
Hypertension, grade 3	≥180	and/or	≥110
Isolated systolic hypertension	≥140	and	<90

Table 9 Similarities and Differences in the 2017 ACC/AHA and 2018 ESC/ESH Adult BP Guidelines

Similarities	Differences
Comprehensive guidelines based on rigorous development processes	Lower SBP and DBP cut points for diagnosis of hypertension in ACC/AHA guideline
Emphasis on accurate BP measurements and use of out-of-office readings	ACC/AHA recommends antihypertensive drug therapy when SBP 130–139 mm Hg or DBP 80-89 mm Hg and CVD or 10-year atherosclerotic CVD risk ≥10%, whereas ESC/ESH recommends drug therapy only be considered for SBP 130–139 mm Hg or DBP 85–89 mm Hg when CVD present, especially coronary heart disease
Use of CVD risk estimation to inform decision for initiation of antihypertensive drug therapy	BP targets somewhat lower in ACC/AHA than in ESC/ESH, especially in older adults and those with chronic kidney disease.
Similar lifestyle change recommendations for prevention and treatment of hypertension	Treatment of other CVD risk factors recommended in both guidelines but ACC/AHA references other ACC/AHA guidelines for specific details, whereas ESC/ESC includes details for statin and aspirin therapy.
Antihypertensive drug therapy recommended when SBP ≥140 mm Hg or DBP ≥90 mm Hg in both guidelines	
Similar core strategy for antihypertensive drug therapy Combination therapy for most adults with hypertension Single-pill combinations preferred If no compelling indication for drug choice, consider initial 2-drug combination of diuretic or calcium channel blockers plus angiotensin converting enzyme inhibitors or angiotensin receptor blockers, followed by a 3-drug combination if necessary	
Lower BP targets compared with previous guidelines	
Strategies to improve adherence and BP control	

Review

OPEN

Management of Hypertension in the Digital Era

Small Wearable Monitoring Devices for Remote Blood Pressure Monitoring

Kazuomi Kario

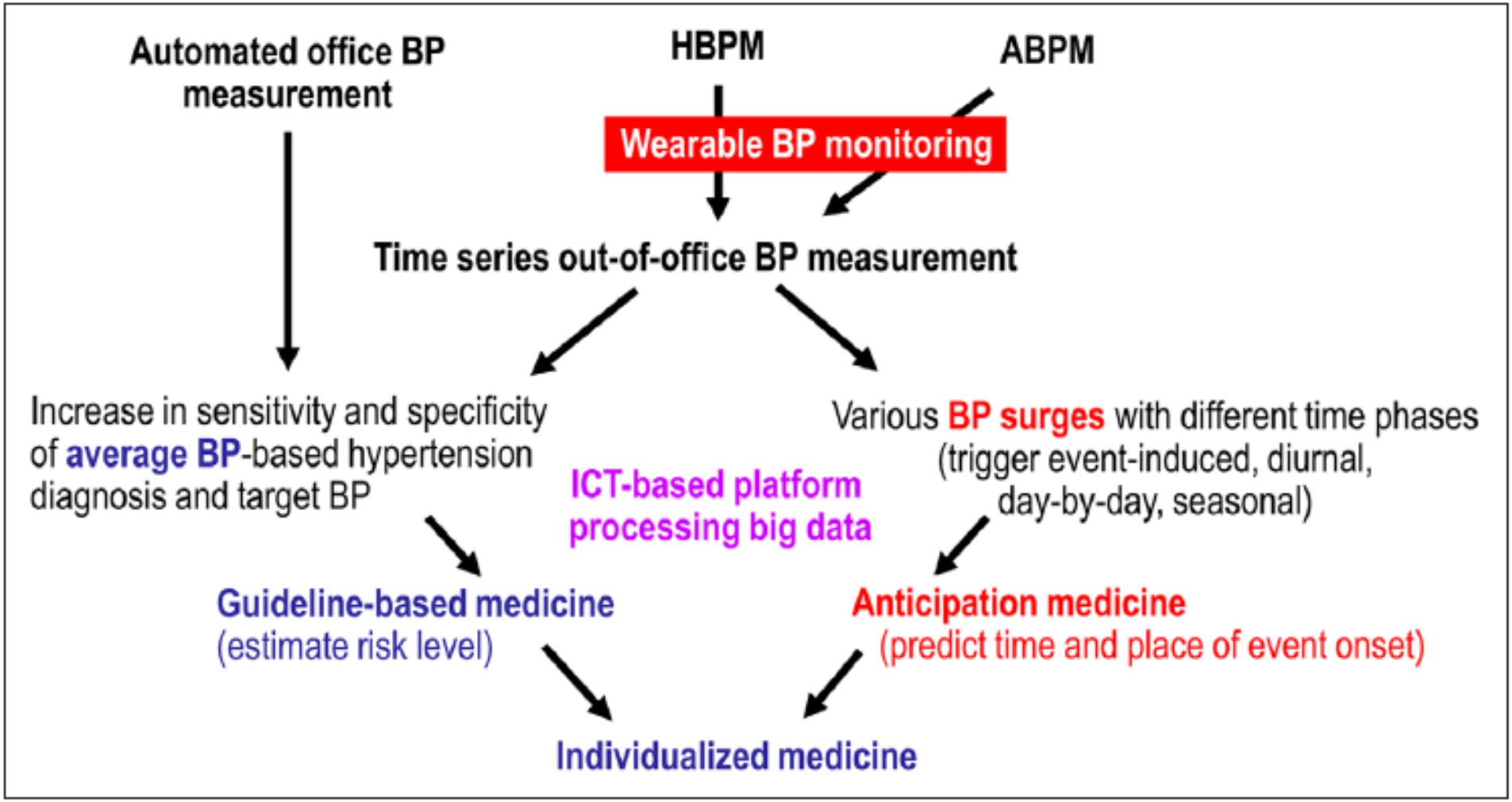
Abstract—Out-of-office blood pressure measurement is an essential part of diagnosing and managing hypertension. In the era of advanced digital health information technology, the approach to achieving this is shifting from traditional methods (ambulatory and home blood pressure monitoring) to wearable devices and technology. Wearable blood pressure monitors allow frequent blood pressure measurements (ideally continuous beat-by-beat monitoring of blood pressure) with minimal stress on the patient. It is expected that wearable devices will dramatically change the quality of detection and management of hypertension by increasing the number of measurements in different situations, allowing accurate detection of phenotypes that have a negative impact on cardiovascular prognosis, such as masked hypertension and abnormal blood pressure variability. Frequent blood pressure measurements and the addition of new features such as monitoring of environmental conditions allows interpretation of blood pressure data in the context of daily stressors and different situations. This new digital approach to hypertension contributes to anticipation medicine, which refers to strategies designed to identify increasing risk and predict the onset of cardiovascular events based on a series of data collected over time, allowing proactive interventions to reduce risk. To achieve this, further research and validation is required to develop wearable blood pressure monitoring devices that provide the same accuracy as current approaches and can effectively contribute to personalized medicine.

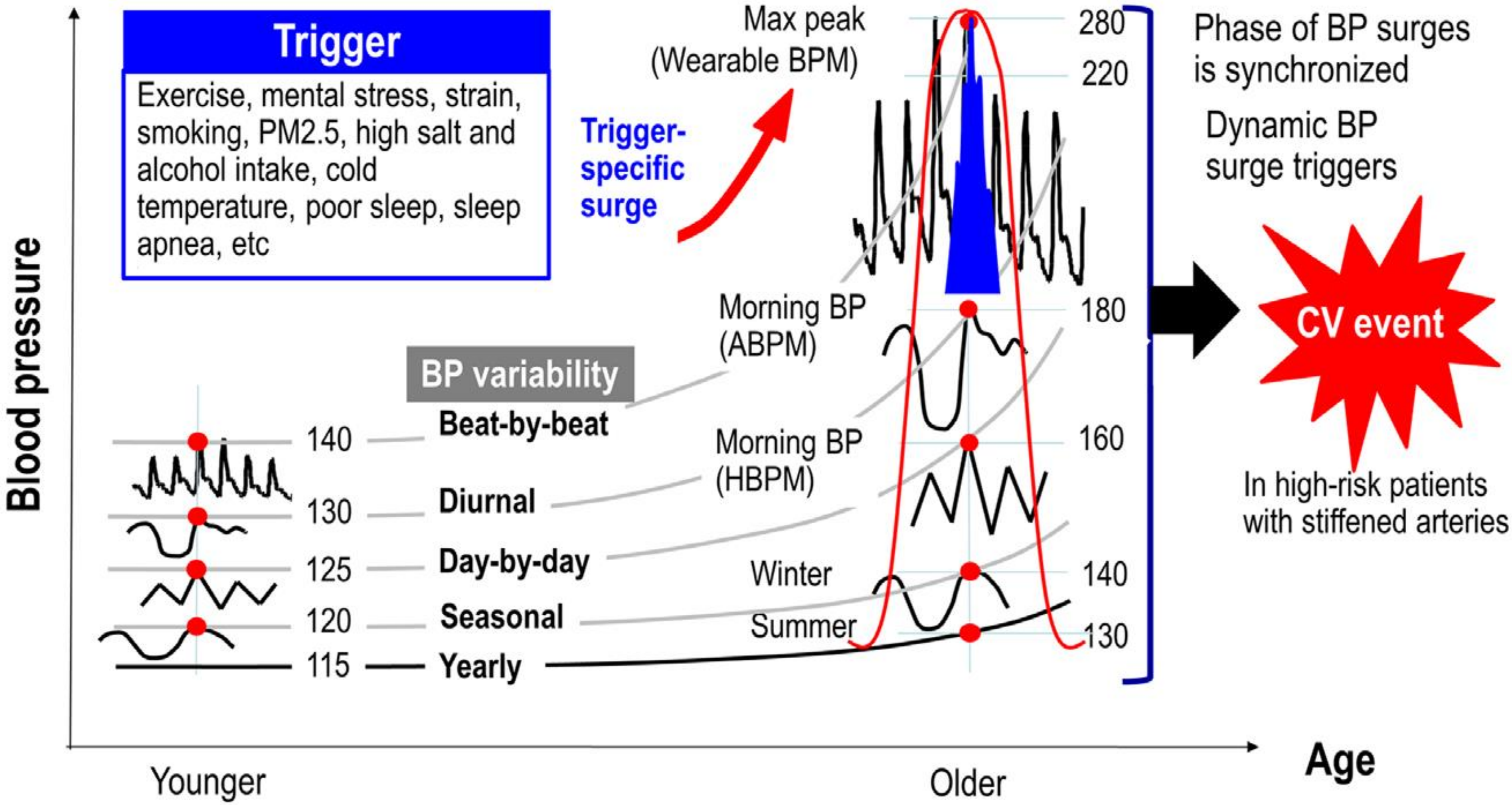
Key Words: blood pressure ■ hypertension ■ phenotype ■ prognosis ■ wearable electronic devices

Out-of-office blood pressure (BP) determined using ambulatory BP monitoring (ABPM) and/or home BP monitoring (HBPM) is recommended for the diagnosis of hypertension in major international guidelines.[1–11] Home and/or ambulatory BP readings have been shown to provide better prognostic information about target organ damage and cardiovascular risk than measurement of office BP.[12–23] However, current approaches to ABPM and HBPM also have a number of well-known limitations, including patient comfort, sleep disturbance, availability, and cost.[24–26]

The ultimate goal is that new information and communication technologies contribute to personalized solutions for hypertension management based on anticipation medicine with the goal of reducing cardiovascular risk (Figure 1).[32] In addition, the availability of big data collected by wearable BP monitoring could facilitate time-series analyses and be used to inform artificial intelligence strategies to predict hypertension.[33,34]

Wearable BP Monitoring Concept and Cardiovascular Risk

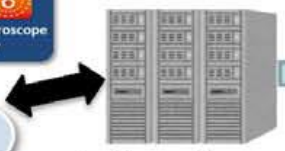

Automated office BP measurement
HBPM
ABPM
Wearable BP monitoring
Time series out-of-office BP measurement
Increase in sensitivity and specificity of average BP-based hypertension diagnosis and target BP
ICT-based platform processing big data
Various BP surges with different time phases (trigger event-induced, diurnal, day-by-day, seasonal)
Guideline-based medicine (estimate risk level)
Anticipation medicine (predict time and place of event onset)
Individualized medicine



Trigger
Exercise, mental stress, strain, smoking, PM2.5, high salt and alcohol intake, cold temperature, poor sleep, sleep apnea, etc
Trigger-specific surge
Max peak (Wearable BPM)
280
220
Phase of BP surges is synchronized
Dynamic BP surge triggers
Morning BP (ABPM)
180
BP variability
CV event
Beat-by-beat
140
Diurnal
130
Morning BP (HBPM)
160
In high-risk patients with stiffened arteries
Day-by-day
125
Winter
140
Seasonal
120
Summer
130
Yearly
115
Blood pressure
Younger
Older
Age

A

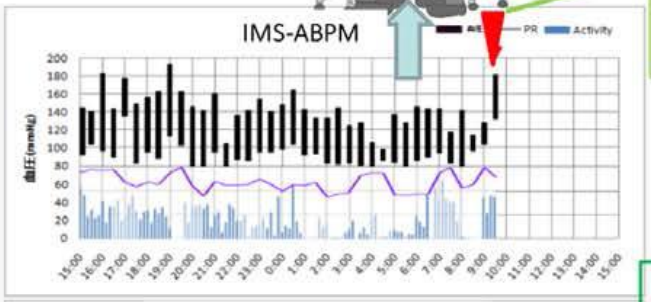
ICT Multisensor environment blood pressure monitoring system

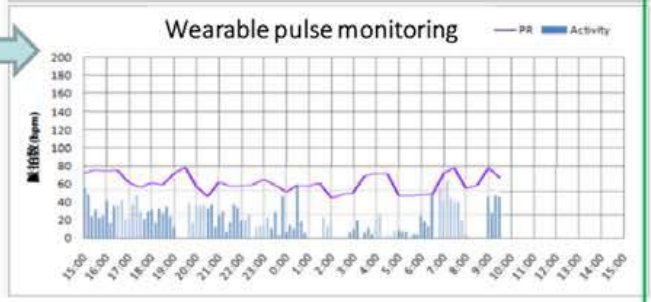


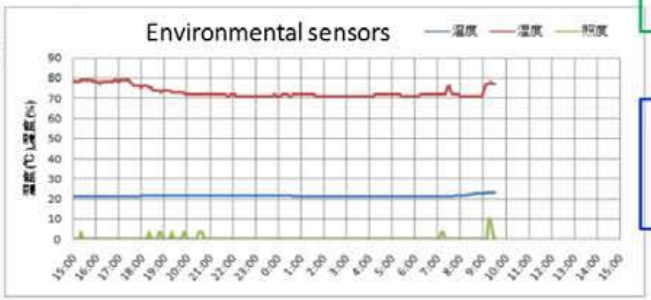
Analyze with server

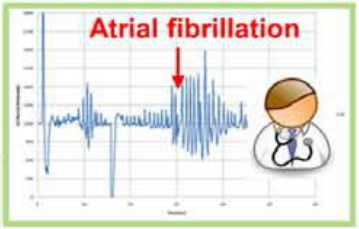
Cloud

Information is transmitted to the Cube from various devices/sensors









IMS-ABPM could be used as a screening for AF by analyzing the waveforms

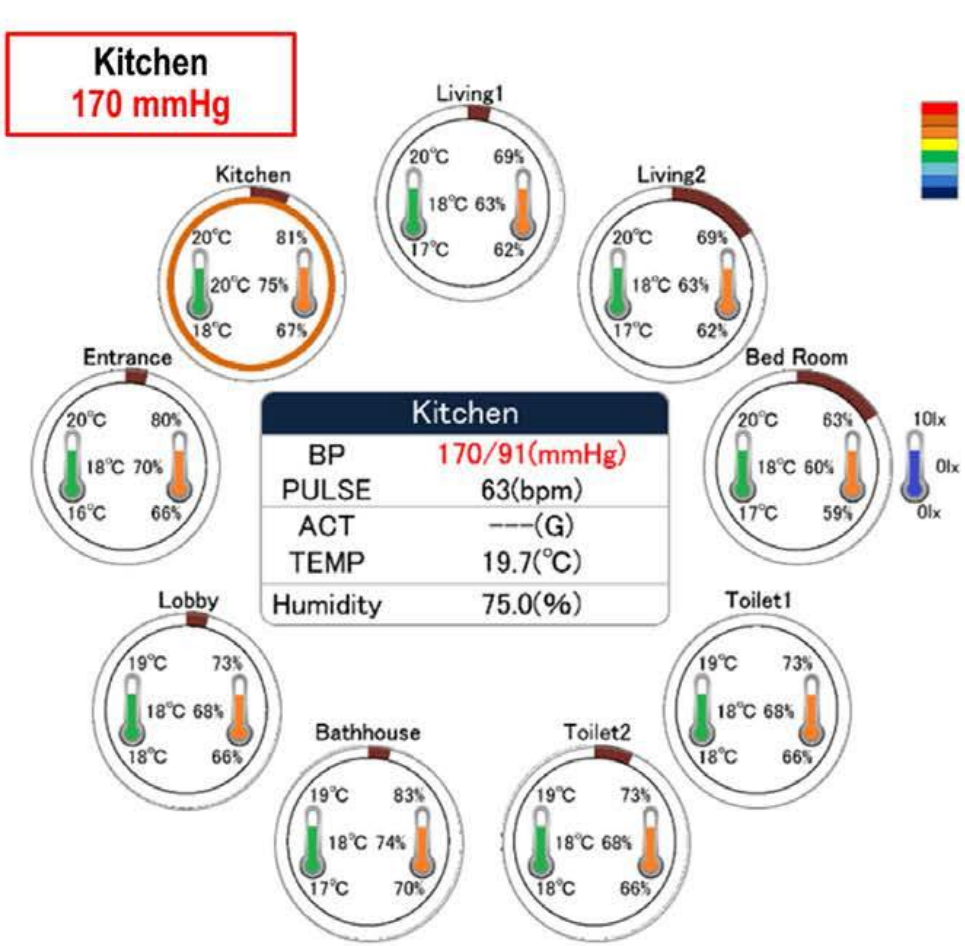
Biological signals

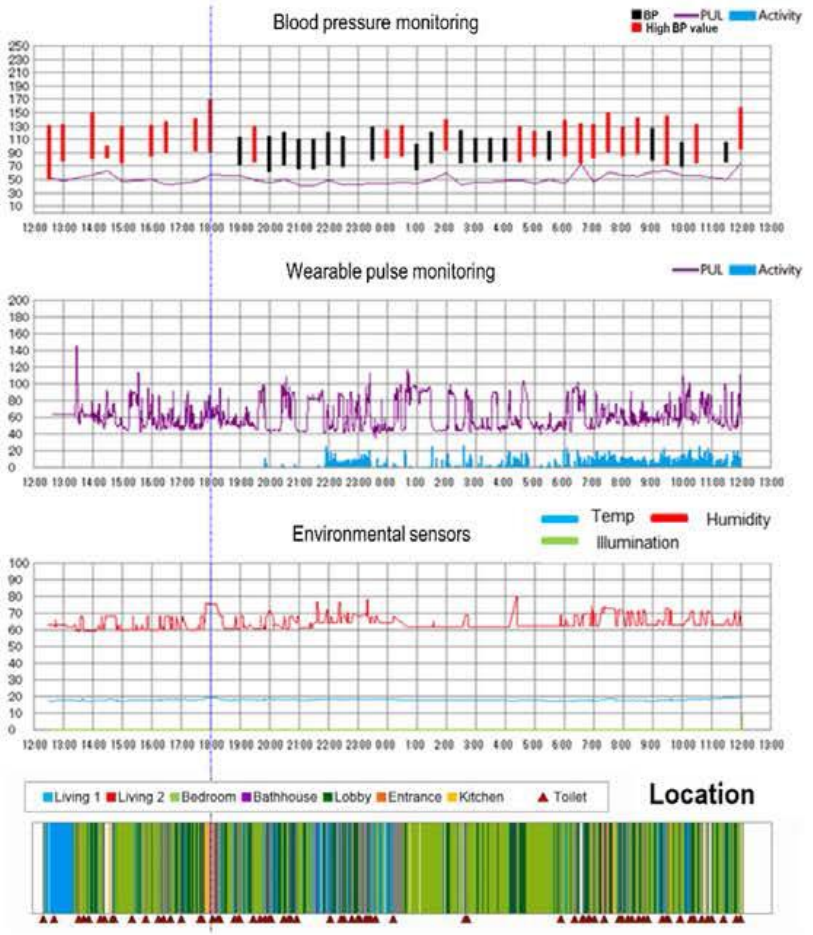
IMS-ABPM:
- Ambulatory BP readings at 30-min intervals (occasional)
- Home BP values
- Pressure waveform
- Activity, temperature, atmospheric pressure

Wearable pulse monitoring:
- Pulse (continuous)
- Physical activity

Environmental signals
- Temperature
- Illumination
- Humidity

B


Kitchen
170 mmHg
Living1
Kitchen
Living2
Entrance
Bed Room
Lobby
Toilet1
Bathhouse
Toilet2
Kitchen
BP 170/91(mmHg)
PULSE 63(bpm)
ACT ---(G)
TEMP 19.7(℃)
Humidity 75.0(%)
10lx
0lx
0lx


Blood pressure monitoring
BP
PUL
Activity
High BP value
Wearable pulse monitoring
PUL
Activity
Environmental sensors
Temp
Humidity
Illumination
Living 1
Living 2
Bedroom
Bathhouse
Lobby
Entrance
Kitchen
Toilet
Location