

# Arterial Hypertension

LECTURE IN INTERNAL MEDICINE FOR V COURSE STUDENTS

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# Preamble

# Internal Medicine Department on Internet: University WEB-portal

The screenshot shows a web browser window with the URL [im.medicine.karazin.ua](https://im.medicine.karazin.ua). The browser's address bar and tabs are visible at the top. The website's navigation menu includes: Home, Educational work, Scientific work, Clinical work, Our journal, and About the Department.

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On our website you will find our recent publications, scientific, educational and clinical presentations. Here we also provide information about other forms of activity of our friendly and ambitious team. We hope that this information will be useful for your everyday creative work. We thank you for visiting our website, and if you have any questions and/or suggestions please do not hesitate to contact us via email [immedi@karazin.ua](mailto:immedi@karazin.ua)

*The Department of Internal Medicine  
V. N. Karazin Kharkiv National University*

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Issue 32

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**Medical Education**

- Ministry of Health of Ukraine
- Ministry of Education and Science of Ukraine
- School of Medicine of V. N. Karazin KhNU
- Kharkiv Medical Academy of Postgraduate Education

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- Department of Internal Medicine in Facebook
- Non-stop HRV, biofeedback and chronotherapy congress
- Meteosensitivity and Meteopathy Website
- Website about health and disease
- Medical Tube

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ENG 20:20 29.08.2017

# Internal Medicine Department on Internet: Facebook

The image shows a screenshot of a Facebook group page titled "HRV & BFB & CHRONOTHERAPY". The browser's address bar shows the URL "https://www.facebook.com/groups/BiofeedbackKhNU/". The page features a blue header with the group name and a search bar. Below the header is a large banner image with a blue-tinted brain and a red heart, overlaid with the text "NON-STOP HRV & BIOFEEDBACK & CHRONOTHERAPY CONGRESS". The left sidebar contains navigation options like "Дискусія", "Учасники", and "Події". The main content area shows a post by "Mykola Iabluchanskyi" with a sun icon and the text "Доспехи метеолата". The right sidebar lists "РЕКОМЕНДОВАНІ ІГРИ" and "РЕКОМЕНДОВАНІ УЧАСНИКИ". The bottom of the image shows the Windows taskbar with various application icons and the system clock displaying "20:19 29.08.2017".

# Internal Medicine Department on Internet: Facebook

The screenshot displays the Facebook profile of the Internal Medicine Department of V.N. Karazin KhNU. The page header includes the name of the department and the profile picture of the administrator, Mykola. The main content area features a large group photo of the department members, with a caption indicating 77 congratulations from Andriy Kudrya and Hamada Amran. Below the photo are navigation tabs for Discussion, Members, Events, Photos, and Files. The page also shows a list of participants, including Boris Tsarbaev, Alexandr Koliada, Inna Vorobьева, Maia Buidze, and Pavel Garkaviy. The page is viewed in a browser window with multiple tabs open, including Google Translate, Meteopathy.com, and Internal Medicine D.

Internal Medicine Dept. of V.N. Karazin KhNU

77 сповіщень від Андрій Кудря та Хамада Амран

Internal Medicine Dept. of V.N. Ka...  
Відкрита група

Дискусія Учасники Події Світлини Файли

Допис Світлина / Відео Опитування Більше

Напишіть що-небудь...

ОСТАННІ ПОДІЇ

Helene Makharynska  
17 год.

ДОДАТИ УЧАСНИКІВ

Введіть ім'я або електронну адресу...

УЧАСНИКИ 961 учасник (12 нових)

ОПИС Редагувати

Dear visitor, present and possible future partner, we are welcom... Показати більше...

ТИП ГРУПИ

Школа чи навчання

Юрій Луценко

ВАШІ ІГРИ

РЕКОМЕНДОВАНІ ІГРИ

Boris Tsarbaev

Alexandr Koliada

Inna Vorobьева

Maia Buidze

Pavel Garkaviy

ГУРТОВІ РОЗМОВИ

Andriy, Kartios, Anna...

# USMLE Step 2 - 1

A 57-year-old female with a history of hypertension comes to the physician because of shortness of breath. She says that she has been experiencing progressively worsening dyspnea while climbing the stairs in her house. She denies both chest pain and dyspnea at rest. She appears comfortable at rest. She is on aspirin and metoprolol. Physical examination shows a regular heart rate and rhythm with absence of murmurs or rubs but does have an S4. Blood pressure is 150/80 mm Hg and pulse 55/min. Pulmonary exam reveals rales at the bases. She has lower extremity edema. Echocardiogram shows increased LV filling pressures with a normal ejection fraction. Which of the following is the next best step?

- A.** Candesartan, **B.** Digoxin, **C.** Reduce the dose of metoprolol, **D.** Verapamil, **E.** Transesophageal echocardiography



# USMLE Step 2 - 2

## The correct answer is A -1

This patient has been diagnosed with diastolic left ventricular dysfunction as a result of long-standing hypertension. The chronic effects of advanced hypertrophy in response to long-standing hypertension are the most likely cause of diastolic left ventricular dysfunction. The concentric hypertrophy leads to a heart that cannot relax during diastole, which manifests clinically as dyspnea on exertion.

The best way to counteract the symptoms of diastolic left ventricular dysfunction is to administer a negative inotropic agent in an attempt to relax the heart during diastole, thus improving filling pressures. The goal heart rate is 55–60. If you push the heart rate down, the heart spends more time in diastole and has more time for diastolic filling. Therefore, you would not want to decrease the dose of metoprolol (**Choice C**). You may also use cardiac calcium channel blockers, such as verapamil or diltiazem (**Choice D**), but you would not want to push the HR <55.

# USMLE Step 2 - 2

## The correct answer is A - 2

This patient has been diagnosed with diastolic left ventricular dysfunction as a result of long-standing hypertension. The chronic effects of advanced hypertrophy in response to long-standing hypertension are the most likely cause of diastolic left ventricular dysfunction. The concentric hypertrophy leads to a heart that cannot relax during diastole, which manifests clinically as dyspnea on exertion.

The best way to counteract the symptoms of diastolic left ventricular dysfunction is to administer a negative inotropic agent in an attempt to relax the heart during diastole, thus improving filling pressures. The goal heart rate is 55–60. If you push the heart rate down, the heart spends more time in diastole and has more time for diastolic filling. Therefore, you would not want to decrease the dose of metoprolol (**Choice C**). You may also use cardiac calcium channel blockers, such as verapamil or diltiazem (**Choice D**), but you would not want to push the HR <55.



# USMLE Step 2 - 3

## The correct answer is A - 2

- In addition to decreasing the heart rate, reducing the afterload with ACE inhibitors or ARBs is also a target for therapy. Candesartan (**Choice A**) has been shown to improve exercise tolerance but not mortality in patients with diastolic dysfunction.
- Digoxin (**Choice B**) has not shown benefit in isolated diastolic heart failure and should not be used unless required for the treatment of coexisting atrial arrhythmias.
- Transesophageal echocardiography (**Choice E**) is not indicated for diastolic left ventricular dysfunction because a transthoracic echo is sufficient to make the diagnosis, which involves documentation of normal or only minimally reduced left ventricular systolic function and evidence of abnormalities of left ventricular relaxation. One of the indications for transesophageal echo is to determine the presence of a thoracic aortic aneurysm.

# Plan of the Lecture

- Definition
- Epidemiology
- Risk factors
- Etiology
- Mechanisms
- Adaptation to arterial hypertension
- Classification
- Clinical investigation
- Diagnosis
- Treatment
- Prognosis
- Prophylaxis
- Abbreviations
- Diagnostic guidelines

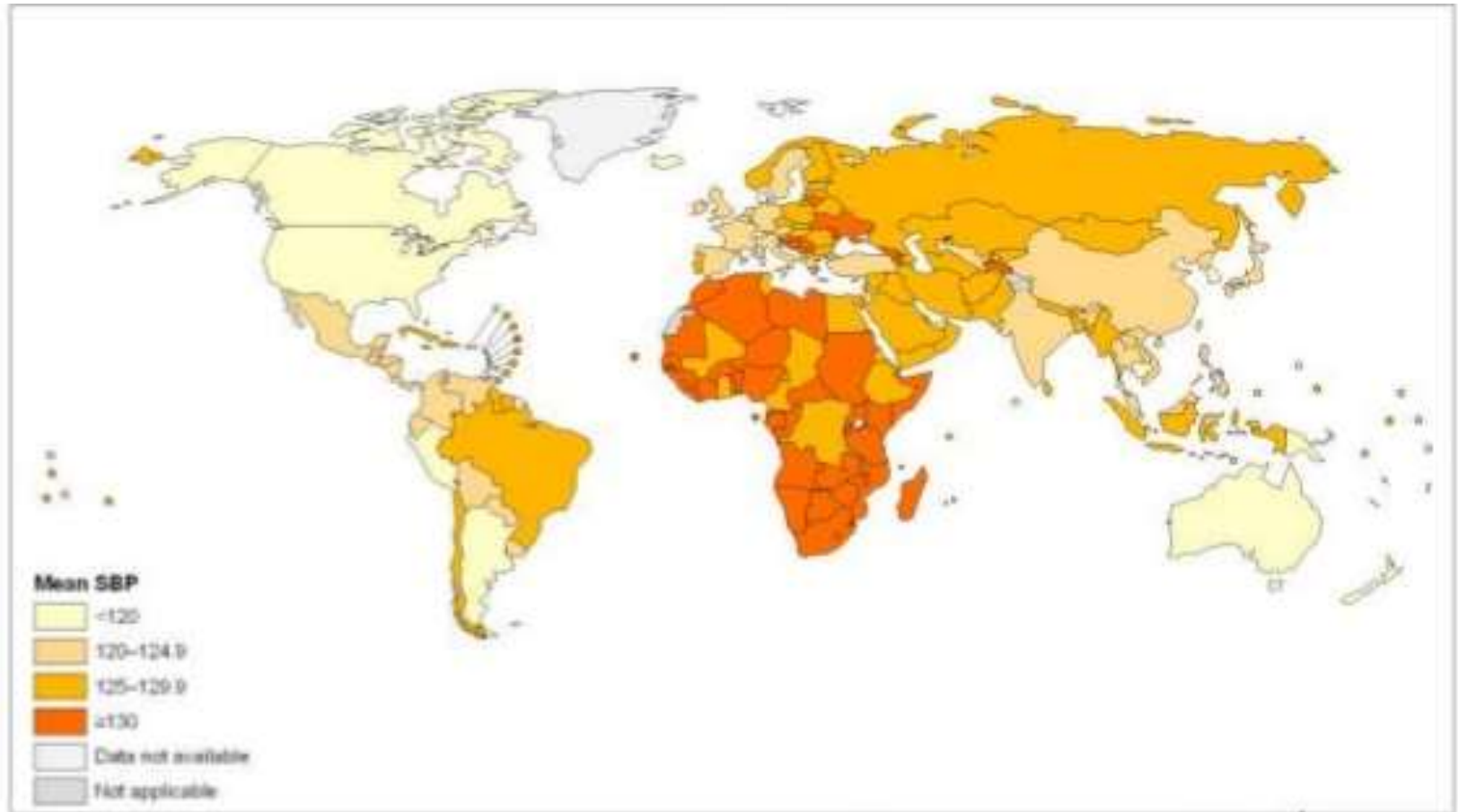


# Definition

- Hypertension (HT), also known as high blood (BP) pressure, is a long term medical condition in which the blood pressure in the arteries is persistently elevated
- HT defined as values  $>140$  mmHg systolic BP (SBP) and/or  $>90$  mmHg diastolic BP (DBP), based on the evidence from randomized control trials (RCTs) that in patients with these BP values treatment-induced BP reductions are beneficial

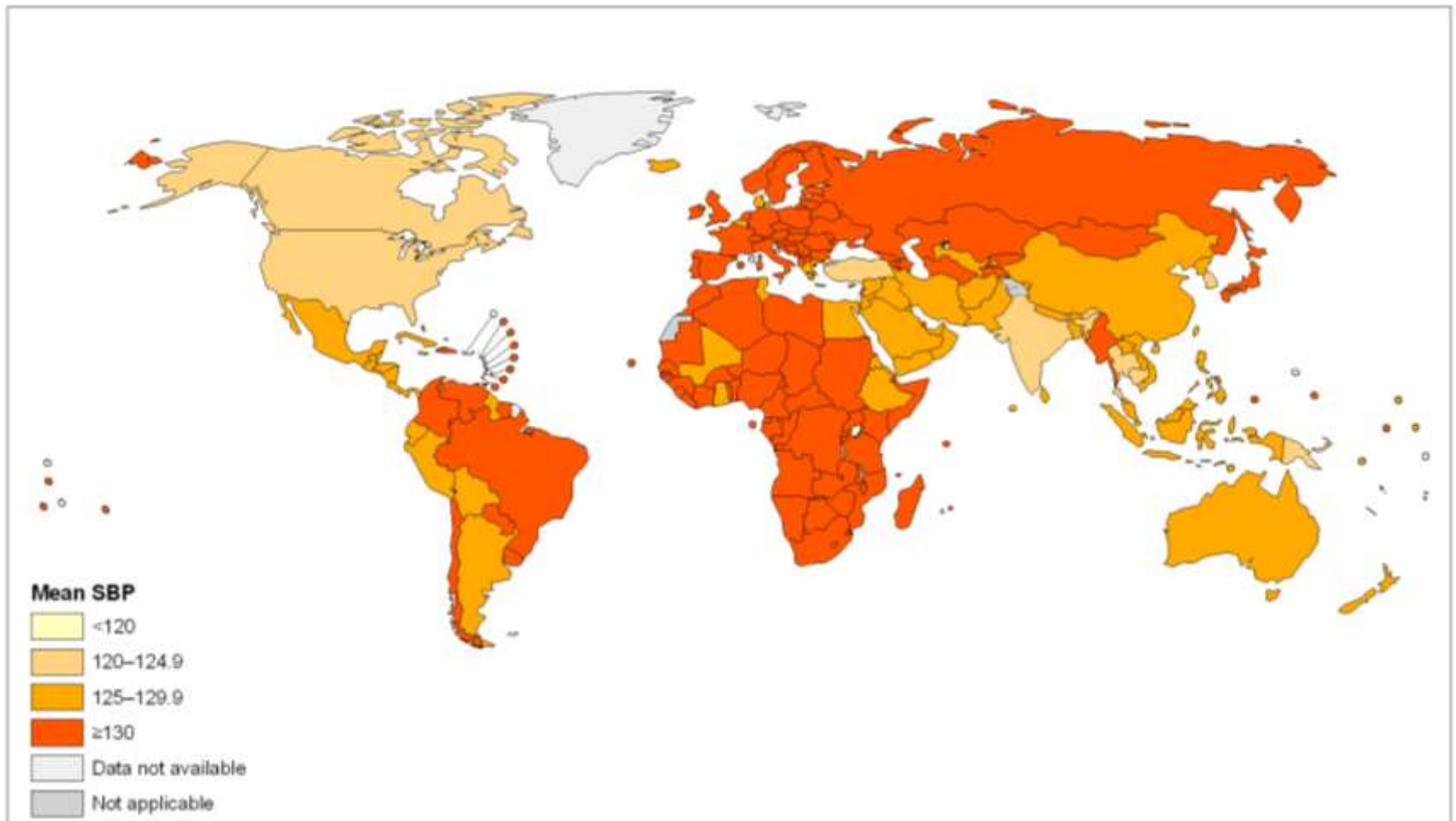
# Epidemiology 1

(Mean Systolic Blood Pressure, Females, Ages 25+)



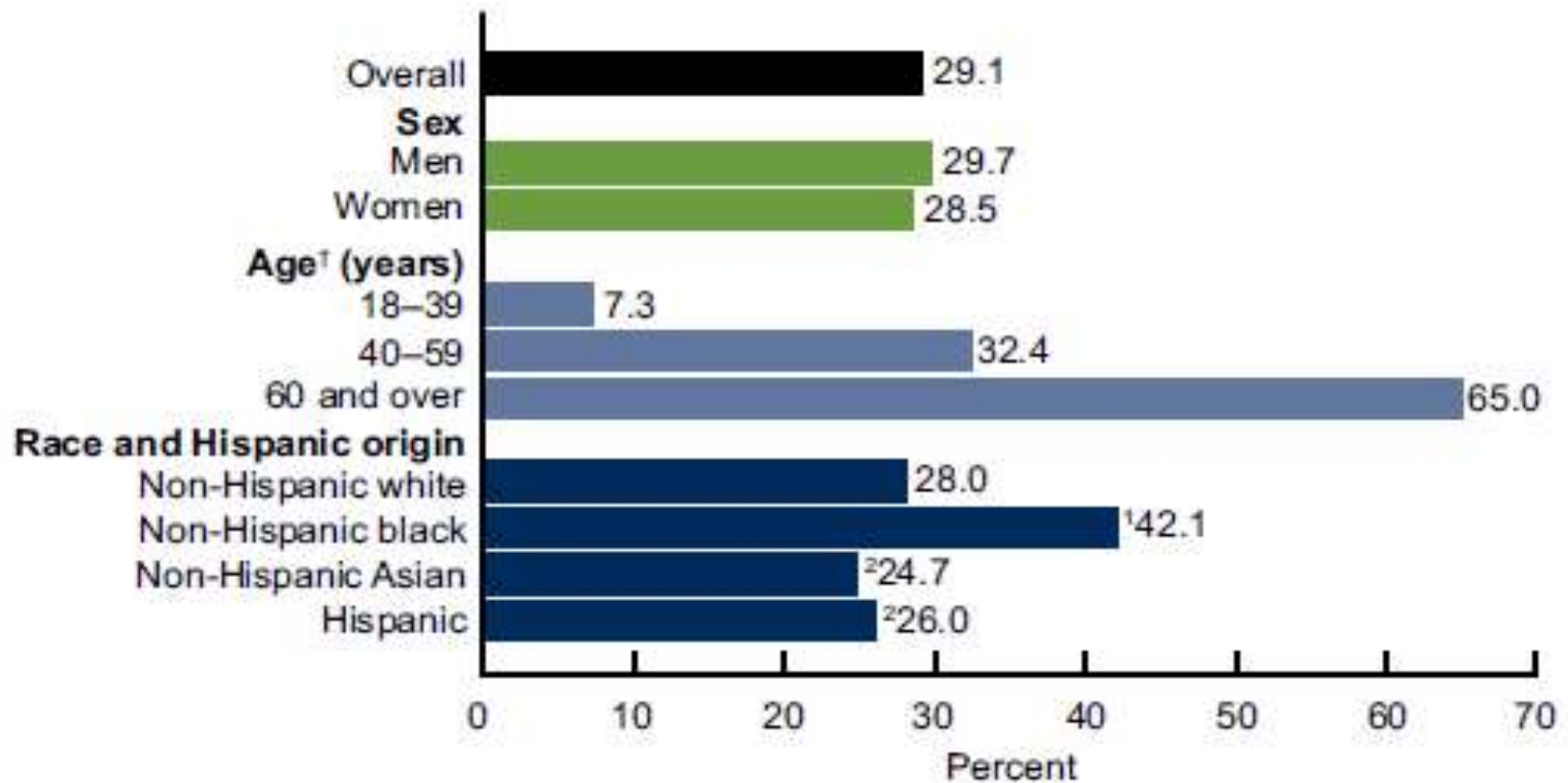
# Epidemiology 2

(Mean Systolic Blood Pressure, Males, Ages 25+)

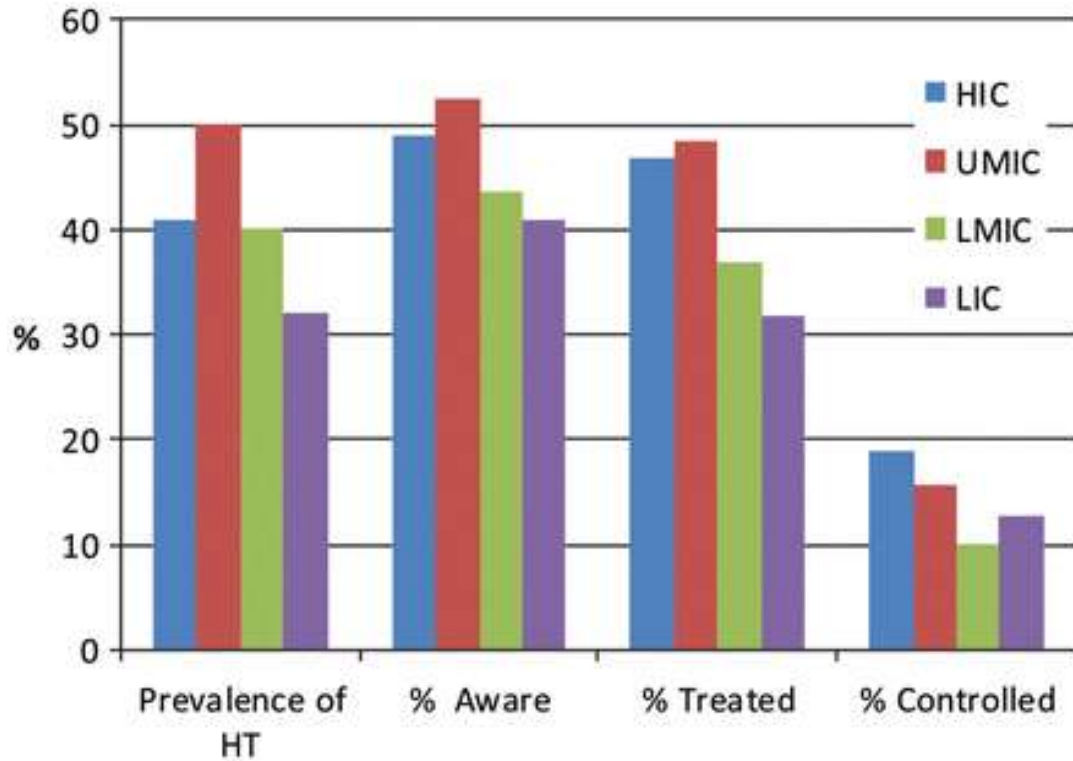


# Epidemiology 3

(Prevalence of High Blood Pressure in USA)



# Epidemiology 4



Percent prevalence, awareness, treatment, and control of HT in urban and rural communities from high-, middle-, and low-income countries. HT controlled is defined as the proportion of participants with HT with SBP < 140 and DBP < 90 mmHg. HIC, high-income countries; UMIC, upper middle-income countries; LMIC, lower middle-income countries; LIC, low-income countries



# Risk Factors

## Changeable hypertension risk factors



Overweight or Obesity



High sodium salt usage



Alcohol use



Lack of physical activity



Smoking

Stress

## Unchangeable hypertension risk factors



Aging



Race



Family history



Gender



Prehypertension or gestational hypertension

# Etiology 1

- HT is classified as either primary (essential) or secondary
- About 90–95% of cases are primary, defined as high blood pressure due to nonspecific lifestyle and genetic factors (lifestyle factors that increase the risk include excess salt, excess body weight, smoking, and alcohol)
- The remaining 5–10% of cases are categorized as secondary HT, defined as HT due to an identifiable cause, such as chronic kidney disease, narrowing of the kidney arteries, an endocrine disorder, or the use of birth control pills

# Etiology (?) 2

## Essential Hypertension Causes



Excess Salt



Abnormal Arteries



Increased Blood volume



Genetic Disorders



Stressful Life

---

## Secondary Hypertension Causes



Health Conditions



Certain Medicines



Recreational Drugs



Pregnancy



Hormonal Therapy

# Mechanisms 1

## (The Control Of Blood Pressure Systems )

- Neurogenic
- Renin-angiotensin
- Atrial natriuretic peptide
- Eicosanoids
- Kallikrein-kinin
- Endothelial
- Adrenal steroids
- Renomedullary vasodepression
- Sodium and water excretion

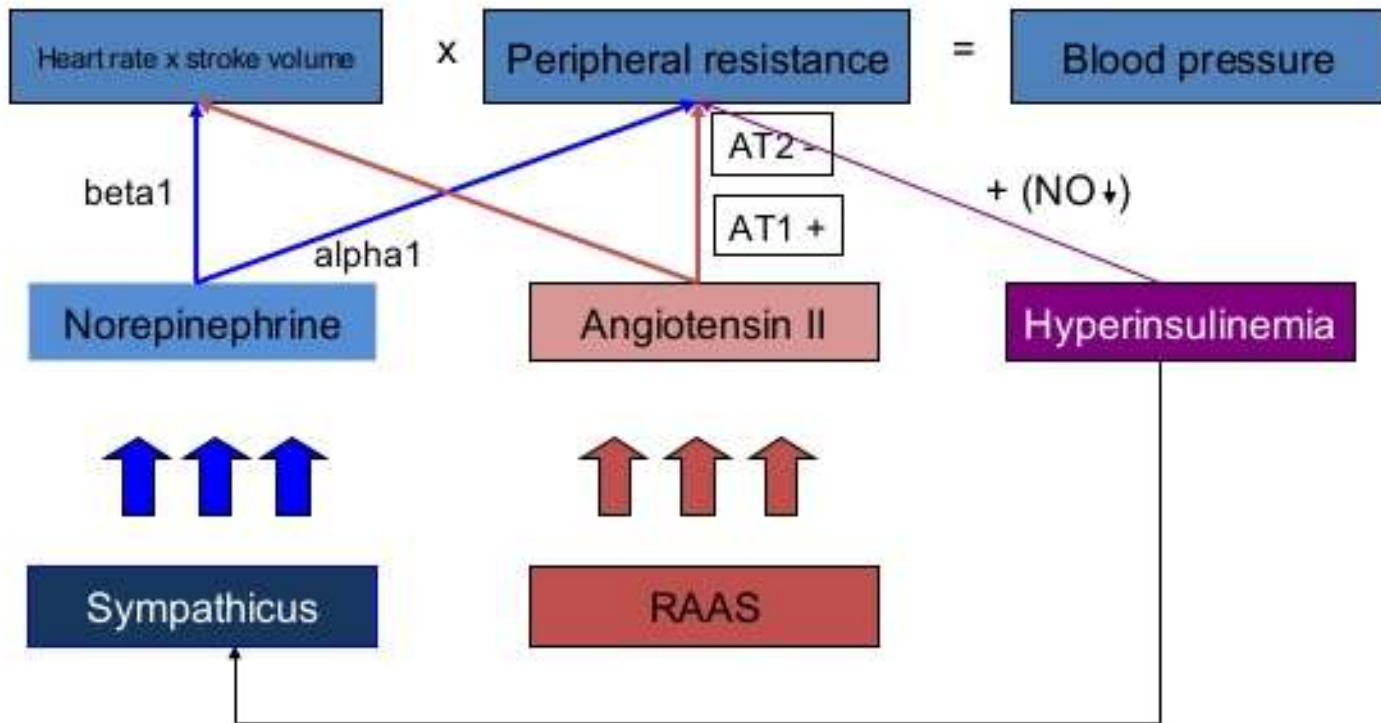
# Mechanisms 2

## (Multifactorial And Highly Complex)

- Humoral mediators
- Vascular reactivity
- Circulating blood volume
- Vascular caliber
- Blood viscosity
- Cardiac output
- Blood vessel elasticity
- Neural stimulation

# Mechanisms 3

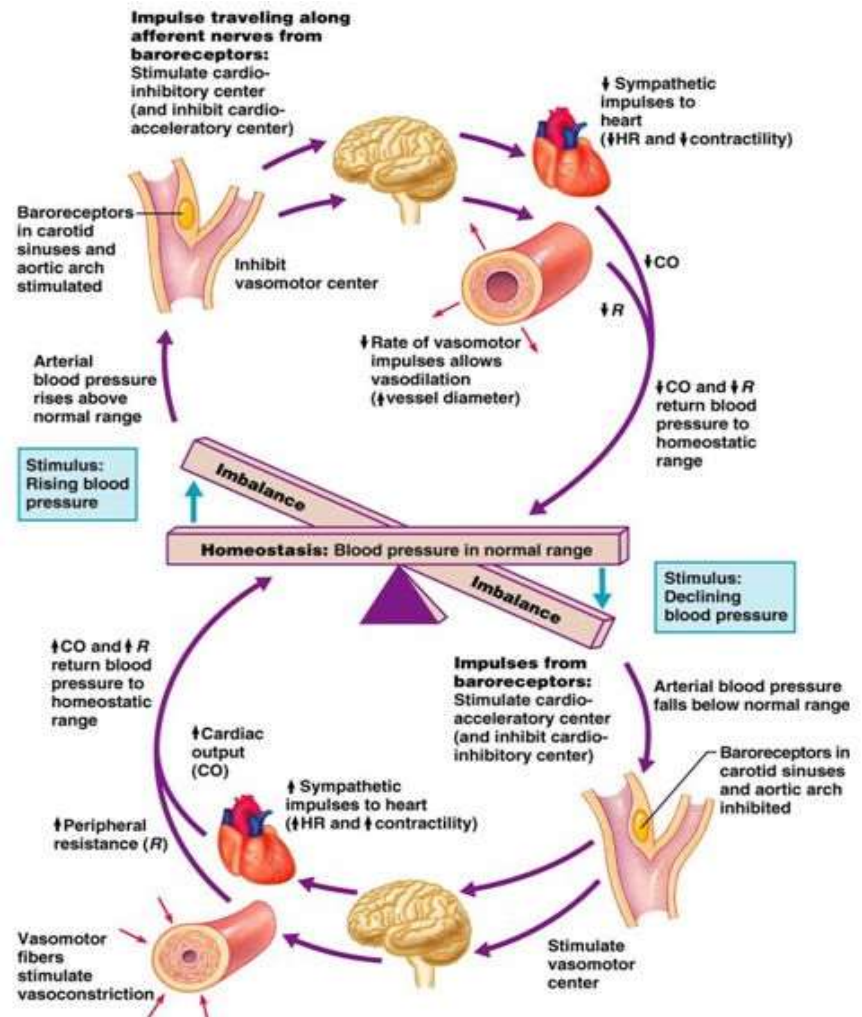
## (Key Points)



# Mechanisms 4

## (Short Term Nervous)

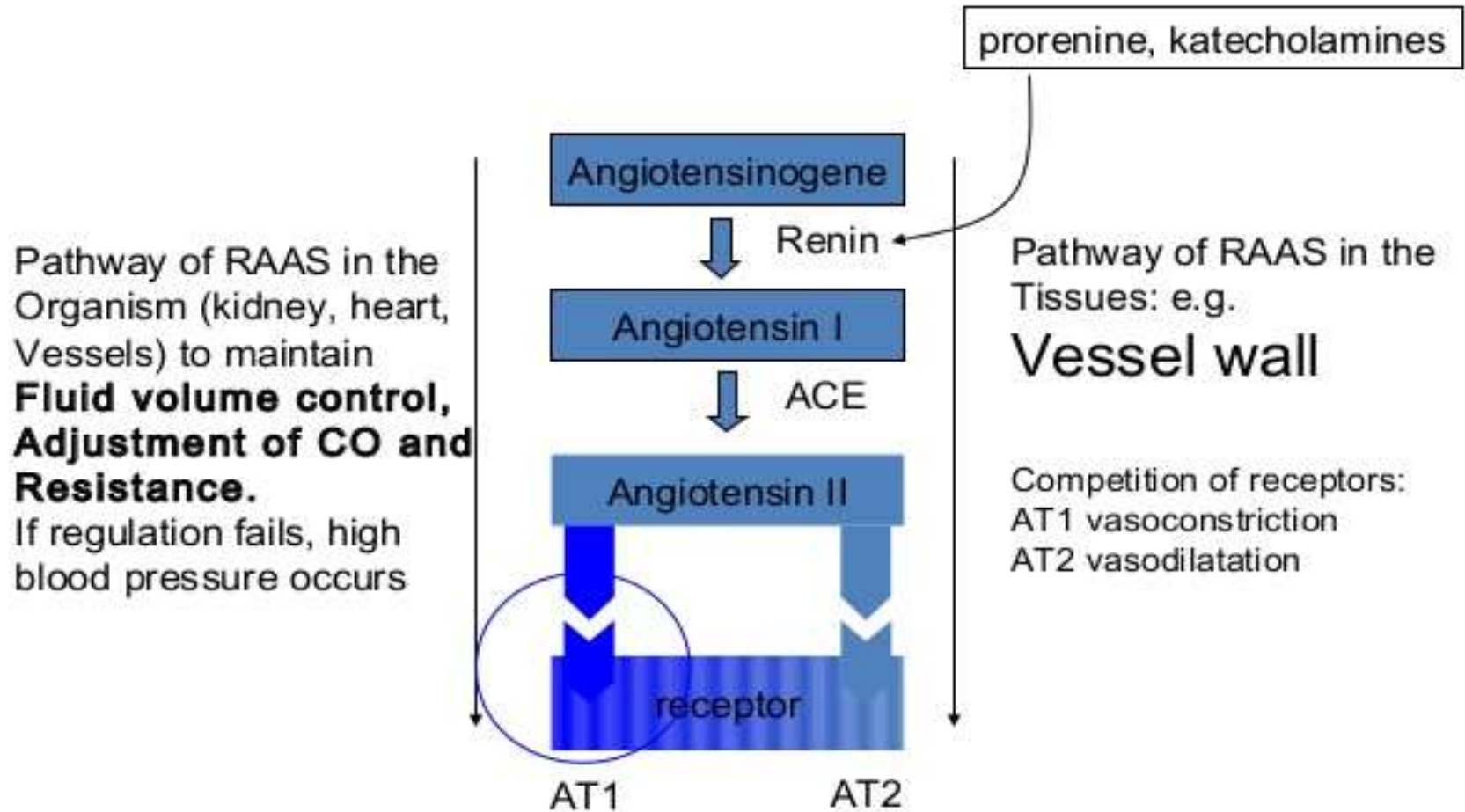
- Baroreceptor initiated reflex
  - located at carotid sinuses and aortic arch
  - monitors blood pressure
  - regulates the activity of the sympathetic nervous system (vascular tone)





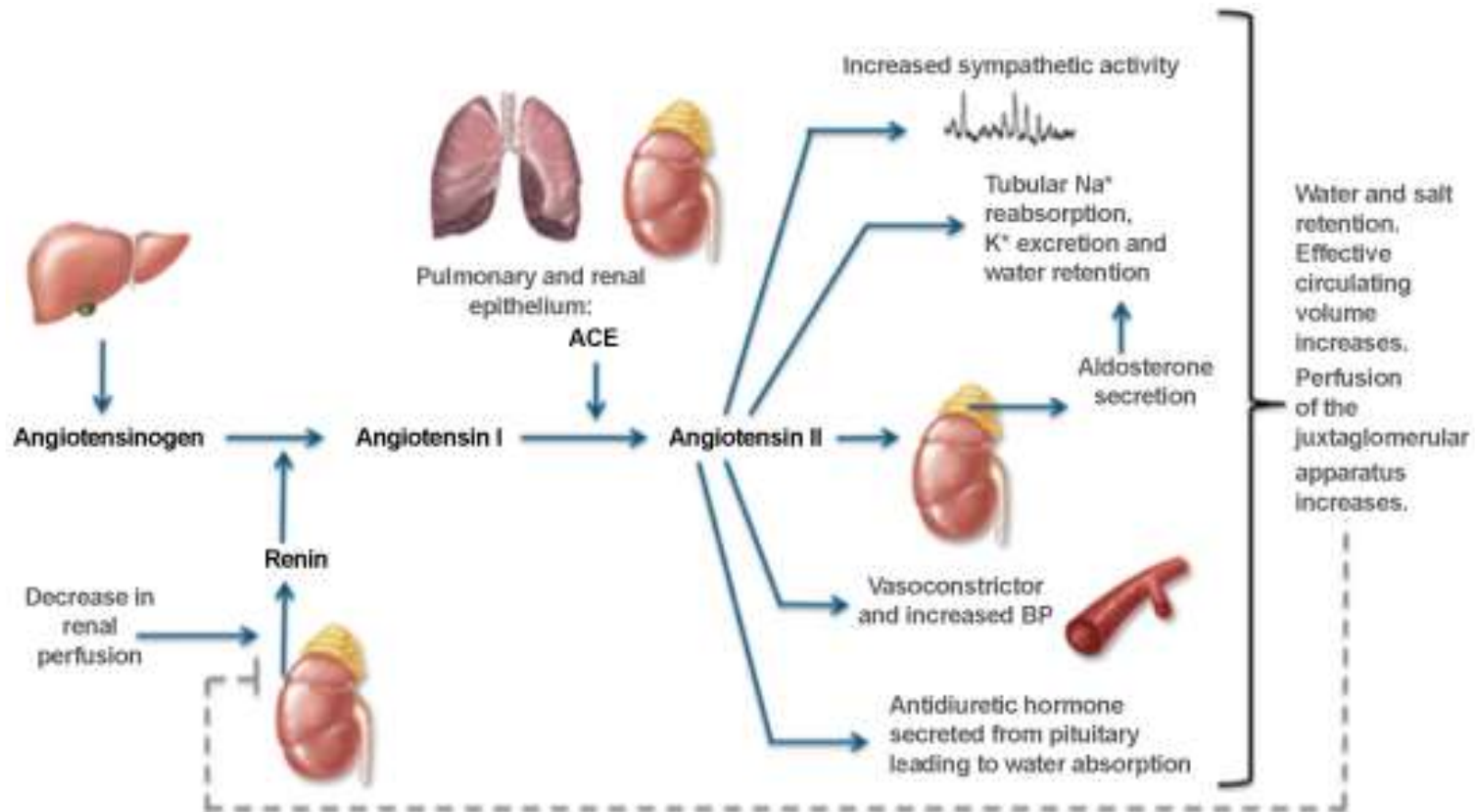
# Mechanisms 5

## (Long Term Humoral)



# Mechanisms 6

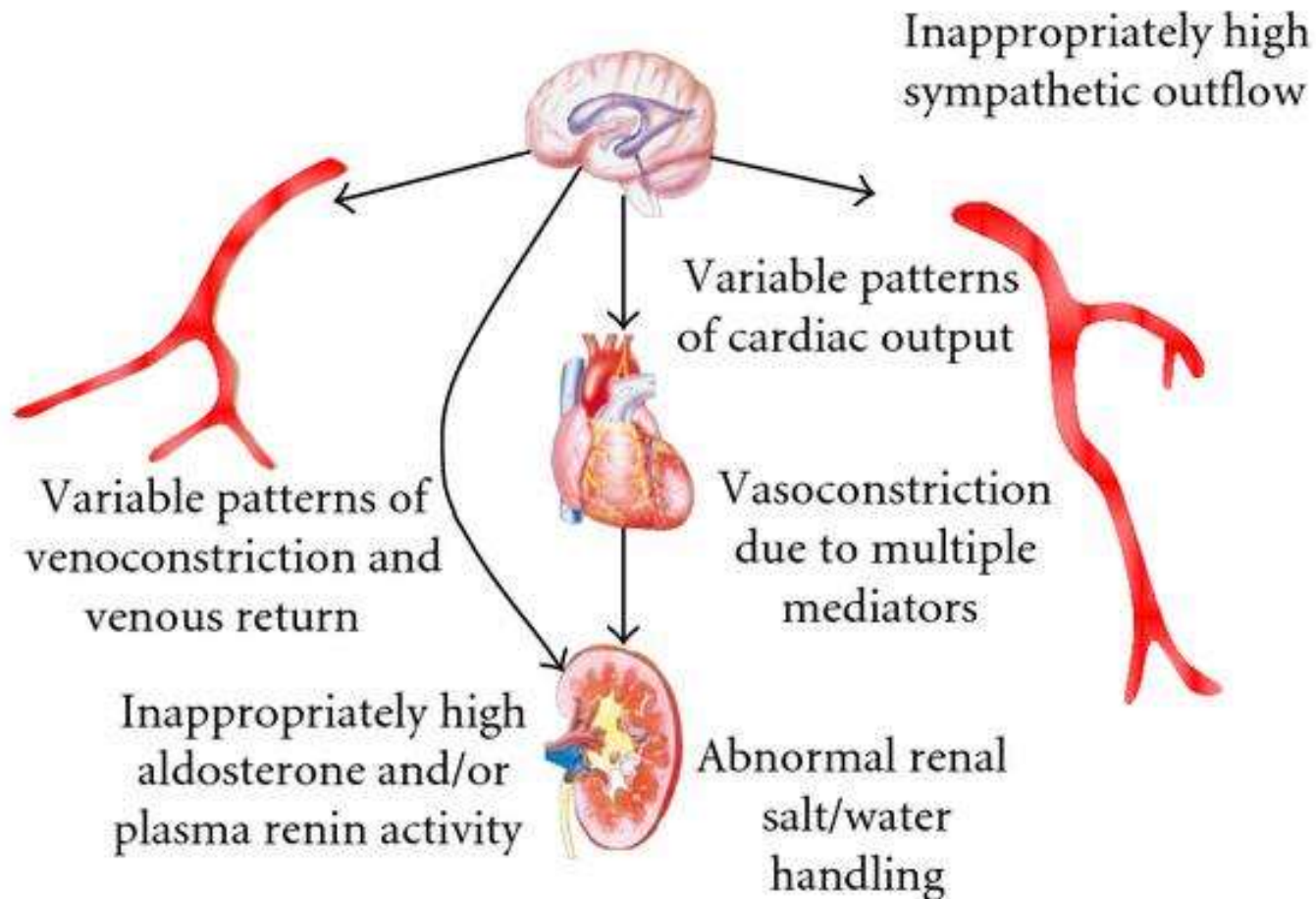
(Combine Peripheral Humoral And Nervous)



# Mechanisms 7

## (Nature of Resistant Hypertension)

Pathophysiology of resistant or difficult-to-treat hypertension



# Adaptation to Arterial Hypertension

It lies on the surface (cardiac and vascular remodelling)

- Cardiac
  - structural remodeling of the left ventricle
    - wall thickening (ventricular hypertrophy)
    - luminal dilatation
- Vascular
  - structural remodeling of muscular and elastic arteries
    - wall thickening (hypertrophy)
    - luminal dilatation

In reality changes take place in all systems and structures

# Classification

## (European Society of Cardiology)

| Category                       | Systolic  |        | Diastolic |
|--------------------------------|-----------|--------|-----------|
| Optimal                        | <120      | and    | <80       |
| Normal                         | 120 - 129 | and/or | 80 - 84   |
| High normal                    | 130 - 139 | and/or | 85 - 89   |
| Grade 1 hypertension           | 140 - 159 | and/or | 90 - 99   |
| Grade 2 hypertension           | 160 - 179 | and/or | 100 - 109 |
| Grade 3 hypertension           | ≥180      | and/or | ≥110      |
| Isolated systolic hypertension | ≥140      | and    | <90       |

The BP category is defined by the highest level of BP, whether systolic or diastolic.

Isolated systolic hypertension should be graded 1, 2, or 3 according to systolic BP values in the ranges indicated.

Office BP is the average of at least 2 BP measurements (with a validated device), spaced 1-2 min apart, after the patient has been sitting for 3-5 min, on at least 2 visits.

# Classification

## (JNC-7 Blood Pressure Classification)

| Blood Pressure Classification | Systolic blood pressure (mm Hg) | Diastolic blood pressure (mm Hg) |
|-------------------------------|---------------------------------|----------------------------------|
| Normal                        | < 120                           | < 80                             |
| Pre-hypertension              | 120-139                         | 80-89                            |
| Stage 1 hypertension          | 140-159                         | 90-99                            |
| Stage 2 hypertension          | $\geq 160$                      | $\geq 100$                       |

# Classification

## (Due to Cause)

- Essential HT *up to 95%*
- Secondary (inessential) HT
  - Renovascular ( fibromuscular dysplasia, atheromatous stenosis, diabetes)
  - Secondary to other renal disorders (chronic renal failure, renal artery stenosis, renal segmental hypoplasia)
  - Secondary to endocrine disorders (pheochromocytoma, hyperaldosteronism (Conn's syndrome), Cushing's syndrome, hyperparathyroidism, acromegaly, hyperthyroidism, hypothyroidism)
  - Other (hormonal contraceptives, neurologic disorders, obstructive sleep apnea, liquorice, scleroderma, neurofibromatosis, pregnancy, cancers, drugs, etc.)



# Classification

## (Resistant HT)

- Resistant HT is defined as HT that remains above goal blood pressure in spite of using, at once, three antihypertensive medications belonging to different drug classes
- Low adherence to treatment is an important cause of resistant HT
- Resistant HT may also represent the result of chronic high activity of the autonomic nervous system (neurogenic hypertension)

# Clinical Investigation

## (Symptoms)

- HT is rarely accompanied by any symptoms, and its identification is usually through screening, or when seeking healthcare for an unrelated problem
- Some with high blood pressure report headaches (particularly at the back of the head and in the morning), as well as lightheadedness, vertigo, tinnitus (buzzing or hissing in the ears), altered vision or fainting episodes
- These symptoms, however, might be related to associated anxiety rather than the high blood pressure itself

# Clinical Investigation

## (Physical Examination)

- Physical examination aims to establish or verify the diagnosis of HT, establish current BP, screen for secondary causes of HT and refine global CV risk estimation
- BP should be repeatedly measured to confirm the diagnosis of HT
- All patients should undergo auscultation of the carotid arteries, heart and renal arteries
- Murmurs should suggest further investigation (carotid ultrasound, echocardiography, renal vascular ultrasound, depending on the location of the murmur)
- Height, weight, and waist circumference should be measured with the patient standing, and BMI calculated
- Pulse palpation and cardiac auscultation may reveal arrhythmias
- Heart rate should be measured while the patient is at rest

# Clinical Investigation

## (Physical Examination: Signs of Secondary HT )

- Features of Cushing syndrome
- Skin stigmata of neurofibromatosis (pheochromocytoma)
- Palpation of enlarged kidneys (polycystic kidney)
- Auscultation of abdominal murmurs (renovascular hypertension)
- Auscultation of precordial or chest murmurs (aortic coarctation; aortic disease; upper extremity artery disease)
- Diminished and delayed femoral pulses and reduced femoral blood pressure compared to simultaneous arm BP (aortic coarctation; aortic disease; lower extremity artery disease)
- Left–right arm BP difference (aortic coarctation; subclavian artery stenosis)

# Clinical Investigation

## (Physical Examination: Signs of Organ Damage)

- Brain: motor or sensory defects
- Retina: fundoscopic abnormalities
- Heart: heart rate, 3rd or 4th heart sound, heart murmurs, arrhythmias, location of apical impulse, pulmonary rales, peripheral oedema
- Peripheral arteries: absence, reduction, or asymmetry of pulses, cold extremities, ischaemic skin lesions
- Carotid arteries: systolic murmurs

# Clinical Investigation

## (Physical Examination: Evidence of Obesity)

- Weight and height
- Calculate BMI:  $\text{body weight} / \text{height}^2$  (kg/m<sup>2</sup>)
- Waist circumference measured in the standing position, at a level midway between the lower border of the costal margin (the lowest rib) and uppermost border of the iliac crest

# Clinical Investigation

## (Hypertensive Crisis)

- Severely elevated blood pressure (equal to or greater than a SBP 180 or DBP 110) is referred to as a hypertensive crisis
- Hypertensive crisis is categorized as either hypertensive urgency or hypertensive emergency, according to the absence or presence of end organ damage, respectively
- In hypertensive urgency oral medications are used to lower the BP gradually over 24 to 48 hours
- In hypertensive emergency, the BP must be reduced more rapidly to stop ongoing organ damage, however, there is a lack of randomised controlled trial evidence for this approach



# Clinical Investigation

## (Outcomes)

- HT is the most important preventable risk factor for premature death worldwide
- HT increases the risk of ischemic heart disease, strokes, peripheral vascular disease, and other cardiovascular diseases, including heart failure, aortic aneurysms, diffuse atherosclerosis, chronic kidney disease, and pulmonary embolism
- HT is also a risk factor for cognitive impairment and dementia
- Other complications include hypertensive retinopathy and hypertensive nephropathy

# Diagnosis

- The evaluation of HT involves accurately measuring the patient's blood pressure, performing a focused medical history and physical examination, and obtaining results of laboratory and instrumental studies
- These steps can help determine the following:
  - Presence of end-organ disease
  - Possible causes of HT
  - Cardiovascular risk factors
  - Baseline values for judging biochemical effects of therapy

# Diagnosis

## (Blood Pressure Measurement)

- Office or clinic blood pressure
- Out-of-office blood pressure
  - Ambulatory blood pressure monitoring
  - Home blood pressure monitoring
- White-coat (or isolated office) HT - 13% (range 9–16%)
- Masked (or isolated ambulatory) HT - 13% (range 10–17%)

# Diagnosis (Office and Out-of-Office Blood Pressure Criteria)

| Category                | Systolic |        | Diastolic |
|-------------------------|----------|--------|-----------|
| <b>Office BP</b>        | ≥140     | and/or | ≥90       |
| <b>Ambulatory BP</b>    |          |        |           |
| - Daytime (or awake)    | ≥135     | and/or | ≥85       |
| - Nighttime (or asleep) | ≥120     | and/or | ≥70       |
| - 24-hour               | ≥130     | and/or | ≥80       |
| <b>Home BP</b>          | ≥135     | and/or | ≥85       |

# Diagnosis

(from True Normotension to Sustained Hypertension)

|                                     |                         | Office BP (mmHg)                |                                      |
|-------------------------------------|-------------------------|---------------------------------|--------------------------------------|
|                                     |                         | SBP <140<br>and DBP <90         | SBP ≥140<br>or DBP ≥90               |
| Daytime ABP<br>or home BP<br>(mmHg) | SBP <135<br>and DBP <85 | True<br>normotension<br>(NT)    | White-coat<br>hypertension<br>(WCHT) |
|                                     | SBP ≥135<br>or DBP ≥85  | Masked<br>hypertension<br>(MHT) | Sustained<br>hypertension<br>(SHT)   |

# Diagnosis (ABPM Derived Variables)

- Night-to-day BP ratio: ratio between average night-time BP and average day-time BP.
- Night-time dipping pattern:

| Category           | Night/day ratio        |
|--------------------|------------------------|
| Absence of dipping | $> 1.0$                |
| Mild dipping       | $> 0.9$ and $\leq 1.0$ |
| Dipping            | $> 0.8$ and $\leq 0.9$ |
| Extreme dipping    | $\leq 0.8$             |

- Additional diagnostic indices such as BP variability, morning BP surge, BP load and ambulatory arterial stiffness index should be regarded as experimental with no routine clinical use, and are discussed in detail in ESH position papers and guidelines.



# Diagnosis

## (Total Cardiovascular Risk Stratification)

| Other risk factors (RF), asymptomatic organ damage (OD) or disease | Blood Pressure (mmHg)                      |   |   |   |
|--|--|---|---|---|
|  | High normal<br>SBP 130-139<br>or DBP 85-89 | Grade 1 HT<br>SBP 140-159<br>or DBP 90-99 | Grade 2 HT<br>SBP 160-179<br>or DBP 100-109 | Grade 3 HT<br>SBP $\geq$ 180<br>or DBP $\geq$ 110 |
| No other RF  |  | Low risk                                  | Moderate risk                               | High risk   |
| 1-2 RF   | Low risk                                   | Moderate risk                             | Moderate to High risk                       | High risk   |
| $\geq$ 3 RF  | Low to moderate risk                       | Moderate to high risk                     | High risk                                   | High risk   |
| OD, CKD stage 3 or diabetes  | Moderate to high risk                      | High risk                                 | High risk                                   | High to very high risk                            |
| Symptomatic CVD, CKD stage $\geq$ 4 or diabetes with OD/RFs        | Very high risk                             | Very high risk                            | Very high risk                              | Very high risk                                    |

# Diagnosis (Risk Factors)

- Male sex.
- Age ( $\geq 55$  yrs in men;  $\geq 65$  yrs in women).
- Smoking.
- Dyslipidaemia:
  - TC  $>4.9$  mmol/L (190 mg/dL), and/or
  - LDL-C  $>3.0$  mmol/L (115 mg/dL), and/or
  - HDL-C  $<1.0$  mmol/L (40 mg/dL) in men;  $<1.2$  mmol/L (46 mg/dL) in women, and/or
  - TG  $>1.7$  mmol/L (150 mg/dL)
- Fasting plasma glucose 5.6-6.9 mmol/L (102-125 mg/dL).
- Abnormal glucose tolerance test.
- Obesity (BMI  $\geq 30$  kg/m<sup>2</sup>).
- Abdominal obesity: waist circumference  $\geq 102$  cm in men;  $\geq 88$  cm in women (in Caucasians).
- Family history of premature CV disease ( $<55$  yrs in men;  $<65$  yrs in women).



# Diagnosis

## (Asymptomatic Organ Damage)

- Pulse pressure  $\geq 60$  mmHg (in the elderly).
- Electrocardiographic LVH (Sokolow-Lyon index  $>3.5$  mV; RaVL  $>1.1$  mV; Cornell voltage duration product  $>244$  mm\*ms), or
- Echocardiographic LVH (LVM index  $>115$  g/m<sup>2</sup> in men;  $>95$  g/m<sup>2</sup> in women).
- Carotid wall thickening (IMT  $>0.9$  mm) or plaque.
- Carotid-femoral pulse wave velocity  $>10$  m/s.
- Ankle-brachial index  $<0.9$ .
- Chronic kidney disease stage 3 (eGFR: 30-60 mL/min/1.73 m<sup>2</sup>).
- Microalbuminuria (30-300 mg/24 h), or albumin-creatinine ratio (30-300 mg/g or 3.4-34 mg/mmol) (preferentially on morning spot urine).

# Diagnosis (Diabetes Mellitus)

- Fasting plasma glucose  $\geq 7.0$  mmol/L (126 mg/dL) on two repeated measurements, and/or
- HbA<sub>1c</sub>  $> 7\%$  (53 mmol/mol), and/or
- Post-load plasma glucose  $> 11.0$  mmol/L (198 mg/dL).

# Diagnosis

## (Established Cardiovascular or Renal Disease)

- Cerebrovascular disease: ischaemic stroke; cerebral haemorrhage; transient ischaemic attack.
- Coronary heart disease: angina; myocardial infarction; revascularization with PCI or CABG.
- Heart failure, including heart failure with preserved ejection fraction.
- Symptomatic lower extremities peripheral artery disease.
- Chronic kidney disease stage 4 (eGFR <30 mL/min/1.73 m<sup>2</sup>).
- Proteinuria >300 mg/24 h.
- Advanced retinopathy: haemorrhages or exudates, papilloedema.



# Diagnosis

## (from Predictive Value to Cost–Effectiveness of Some Markers of Organ Damage)

| Marker                                    | Cardiovascular predictive value | Availability | Reproducibility | Cost-effectiveness |
|---|---------------------------------|--------------|-----------------|--------------------|
| Electrocardiography                       | +++                             | ++++         | ++++            | ++++               |
| Echocardiography, plus Doppler            | ++++                            | +++          | +++             | +++                |
| Estimated glomerular filtration rate      | +++                             | ++++         | ++++            | ++++               |
| Microalbuminuria                          | +++                             | ++++         | ++              | ++++               |
| Carotid intima–media thickness and plaque | +++                             | +++          | +++             | +++                |
| Arterial stiffness (pulse wave velocity)  | +++                             | ++           | +++             | +++                |
| Ankle–brachial index                      | +++                             | +++          | +++             | +++                |
| Fundoscopy                                | +++                             | ++++         | ++              | +++                |
| <i>Additional measurements</i>            |                                 |              |                 |                    |
| Coronary calcium score                    | ++                              | +            | +++             | +                  |
| Endothelial dysfunction                   | ++                              | +            | +               | +                  |
| Cerebral lacunae/white matter lesions     | ++                              | +            | +++             | +                  |
| Cardiac magnetic resonance                | ++                              | +            | +++             | ++                 |

Scores are from + to + + + +.

# Diagnosis (Routine Tests)

- Hemoglobin and/or hematocrit
- Fasting plasma glucose
- Serum total cholesterol, low-density lipoprotein cholesterol, high-density lipoprotein cholesterol
- Fasting serum triglycerides
- Serum potassium and sodium
- Serum uric acid
- Serum creatinine (with estimation of GFR)
- Urine analysis: microscopic examination; urinary protein by dipstick test; test for microalbuminuria
- 12-lead ECG

# Diagnosis (Additional Tests)

- Hemoglobin A1c (if fasting plasma glucose is  $>5.6$  mmol/L (102 mg/dL) or previous diagnosis of diabetes)
- Quantitative proteinuria (if dipstick test is positive); urinary potassium and sodium concentration and their ratio
- Home and 24-h ambulatory BP monitoring
- Echocardiogram
- Exercise testing, Holter monitoring in case of arrhythmias
- Carotid ultrasound
- Peripheral artery/abdominal ultrasound
- Pulse wave velocity
- Ankle-brachial index
- Fundoscopy

# Diagnosis

## (Extended Evaluation)

- Further search for cerebral, cardiac, renal, and vascular damage, mandatory in resistant and complicated hypertension
- Search for secondary hypertension when suggested by history, physical examination, or routine and additional tests

# Treatment (Strategies)

- Patient education
- Lifestyle changes
- Pharmacological therapy



# Treatment

## (Lifestyle Changes)

- Salt restriction
- Moderation of alcohol consumption
- Other dietary changes (vegetables, low-fat dairy products, dietary and soluble fibers, whole grains and protein from plant sources, reduced in saturated fat and cholesterol)
- Weight reduction
- Regular physical exercise
- Smoking cessation

# Treatment

## (Pharmacotherapy)

- Diuretics (including thiazides, chlorthalidone and indapamide)
- Beta-blockers
- Calcium antagonists
- Angiotensin-converting enzyme (ACE) inhibitors
- Angiotensin receptor blockers
- Renin inhibitors
- Other antihypertensive agents (alpha-receptor blockers)
- Monotherapy and combination therapy

# USMLE

1. A 56-year-old man comes to the clinic for a return visit. During his last three visits, he has had an elevated blood pressure in the range of 150-160 mm Hg systolic pressure over 90-95 mm Hg diastolic. Despite 3-6 months of a new diet and exercise program, he has not been able to get his blood pressure under control. His past medical history, except for his high blood pressure, is unremarkable. He is concerned about high blood pressure, as his older brother had high blood pressure and died from a heart attack in his mid 60s. Today his blood pressure is 162/92 mm Hg. Which of the following is the most appropriate, cost-effective, first-line treatment for this patient?

A. Acetazolamide, B. Clonidine, C. Felodipine, D. Hydrochlorothiazide, E. Lisinopril, F. Metoprolol, G. None, continue diet and exercise, H. Spironolactone, I. Terazosin, J. Triamterene

# USMLE

A 62-year-old man comes to the clinic complaining of urinary hesitancy, 3-4 episodes of nocturia per night, and a weak urinary stream. His past medical history is significant for stage I hypertension that persists despite diet and exercise. Physical examination confirms the patient's mild hypertension and a suspected enlarged, symmetric, and non-nodular prostate. In considering antihypertensive treatment, which of the following is a medication that can treat this patient's urinary symptoms and his mild hypertension?

A. Atenolol, B. Doxazosin, C. Felodipine, D. Finasteride, E. Hydrochlorothiazide

# Treatment

## (Compelling and Possible Contra-Indications to the Use of Antihypertensive Drugs)

| Drug                                       | Compelling  | Possible   |
|--|---|--|
| Diuretics (thiazides)                      | Gout  | Metabolic syndrome<br>Glucose intolerance<br>Pregnancy<br>Hypercalcaemia<br>Hypokalaemia   |
| Beta-blockers                              | Asthma<br>A–V block (grade 2 or 3)  | Metabolic syndrome<br>Glucose intolerance<br>Athletes and physically active patients<br>Chronic obstructive pulmonary disease (except for vasodilator beta-blockers) |
| Calcium antagonists (dihydropyridines)     |   | Tachyarrhythmia<br>Heart failure   |
| Calcium antagonists (verapamil, diltiazem) | A–V block (grade 2 or 3, trifascicular block)<br>Severe LV dysfunction<br>Heart failure |  |
| ACE inhibitors                             | Pregnancy<br>Angioneurotic oedema<br>Hyperkalaemia<br>Bilateral renal artery stenosis   | Women with child bearing potential   |
| Angiotensin receptor blockers              | Pregnancy<br>Hyperkalaemia<br>Bilateral renal artery stenosis                           | Women with child bearing potential   |
| Mineralocorticoid receptor antagonists     | Acute or severe renal failure (eGFR <30 mL/min)<br>Hyperkalaemia                        |  |

A–V = atrio-ventricular; eGFR = estimated glomerular filtration rate; LV = left ventricular.

# Treatment

## (Drugs to be Preferred in Specific Conditions)

| Condition                                     | Drug   |
|---|--|
| Asymptomatic organ damage                     |  |
| LVH   | ACE inhibitor, calcium antagonist, ARB                                   |
| Asymptomatic atherosclerosis                  | Calcium antagonist, ACE inhibitor  |
| Microalbuminuria                              | ACE inhibitor, ARB   |
| Renal dysfunction                             | ACE inhibitor, ARB   |
| Clinical CV event                             |  |
| Previous stroke                               | Any agent effectively lowering BP  |
| Previous myocardial infarction                | BB, ACE inhibitor, ARB   |
| Angina pectoris                               | BB, calcium antagonist   |
| Heart failure                                 | Diuretic, BB, ACE inhibitor, ARB, mineralocorticoid receptor antagonists |
| Aortic aneurysm                               | BB   |
| Atrial fibrillation, prevention               | Consider ARB, ACE inhibitor, BB or mineralocorticoid receptor antagonist |
| Atrial fibrillation, ventricular rate control | BB, non-dihydropyridine calcium antagonist                               |
| ESRD/proteinuria                              | ACE inhibitor, ARB   |
| Peripheral artery disease                     | ACE inhibitor, calcium antagonist  |
| Other   |  |
| ISH (elderly)                                 | Diuretic, calcium antagonist   |
| Metabolic syndrome                            | ACE inhibitor, ARB, calcium antagonist                                   |
| Diabetes mellitus                             | ACE inhibitor, ARB   |
| Pregnancy                                     | Methyldopa, BB, calcium antagonist                                       |
| Blacks  | Diuretic, calcium antagonist   |

ACE = angiotensin-converting enzyme; ARB = angiotensin receptor blocker; BB = beta-blocker; BP = blood pressure; CV = cardiovascular; ESRD = end-stage renal disease; ISH = isolated systolic hypertension; LVH = left ventricular hypertrophy.

# Treatment

## (Blood Pressure Goals)

|   |                     |
|---|---------------------|
| <b>SBP goal for “most”</b> <ul style="list-style-type: none"><li>•Patients at low–moderate CV risk</li><li>•Patients with diabetes</li><li>•Consider with previous stroke or TIA</li><li>•Consider with CHD</li><li>•Consider with diabetic or non-diabetic CKD</li></ul> | <b>&lt;140 mmHg</b> |
| <b>SBP goal for elderly</b> <ul style="list-style-type: none"><li>•Ages &lt;80 years</li><li>•Initial SBP <math>\geq</math>160 mmHg</li></ul>   | <b>140-150 mmHg</b> |
| <b>SBP goal for fit elderly</b><br>Aged <80 years   | <b>&lt;140 mmHg</b> |
| <b>SBP goal for elderly &gt;80 years with SBP</b> <ul style="list-style-type: none"><li>•<math>\geq</math>160 mmHg</li></ul>  | <b>140-150 mmHg</b> |
| <b>DBP goal for “most”</b>  | <b>&lt;90 mmHg</b>  |
| <b>DB goal for patients with diabetes</b>   | <b>&lt;85 mmHg</b>  |

# Treatment

## (for People with Diabetes)

| Recommendations  | Additional considerations  |
|--|--|
| <p><b>Mandatory:</b> initiate drug treatment in patients with SBP <math>\geq 160</math> mmHg</p>   | <ul style="list-style-type: none"> <li>• Strongly recommended: start drug treatment when SBP <math>\geq 140</math> mmHg</li> </ul>                               |
| <p><b>SBP goals for patients with diabetes: <math>&lt;140</math> mmHg</b></p>                      |  |
| <p><b>DBP goals for patients with diabetes: <math>&lt;85</math> mmHg</b></p>                       |  |
| <p>All hypertension treatment agents are recommended and may be used in patients with diabetes</p> | <ul style="list-style-type: none"> <li>• RAS blockers may be preferred</li> <li>• <i>Especially in presence of preproteinuria or microalbuminuria</i></li> </ul> |
| <p>Choice of hypertension treatment must take comorbidities into account</p>                       |  |
| <p>Coadministration of RAS blockers <i>not recommended</i></p>                                     | <ul style="list-style-type: none"> <li>• <i>Avoid in patients with diabetes</i></li> </ul>   |



# Treatment

## (for People with Nephropathy)

| Recommendations   | Additional considerations   |
|---|---|
| <b>Consider lowering SBP to &lt;140 mmHg</b>                        |   |
| Consider SBP <130 mmHg with overt proteinuria                       | <ul style="list-style-type: none"> <li>• Monitor changes in eGFR</li> </ul>   |
| RAS blockers more effective to reduce albuminuria than other agents | <ul style="list-style-type: none"> <li>• Indicated in presence of microalbuminuria or overt proteinuria</li> </ul>  |
| Combination therapy usually required to reach BP goals              | <ul style="list-style-type: none"> <li>• Combine RAS blockers with other agents</li> </ul>  |
| Combination of two RAS blockers                                     | <ul style="list-style-type: none"> <li>• <i>Not recommended</i></li> </ul>  |
| Aldosterone antagonist <i>not recommended in CKD</i>                | <ul style="list-style-type: none"> <li>• Especially in combination with a RAS blocker</li> <li>• Risk of excessive reduction in renal function, hyperkalemia</li> </ul> |

# Treatment

## (Comparison of Recent Guideline Statements)

|                             | <u>JNC 8</u>                      | <u>ESH/ESC</u>                                    | <u>AHA/ACC</u> | <u>ASH/ISH</u>                   |
|-----------------------------|-----------------------------------|---|----------------|----------------------------------|
|                             |                                   | ≥140/90   |                |                                  |
| Threshold for Drug Rx       | ≥140/90 < 60 yr<br>≥150/90 ≥60 yr | Eldery SBP ≥160<br>Consider SBP 140-150 if <80 yr | ≥140/90        | ≥140/90 <80 yr<br>≥150/90 ≥80 yr |
| B-blocker First line Rx     | No                                | Yes   | No             | No                               |
| Initiate Therapy w/ 2 drugs | ≥160/100                          | "Markedly elevated BP"                            | ≥160/100       | ≥160/100                         |

# Treatment

## (Goal Blood Pressure)

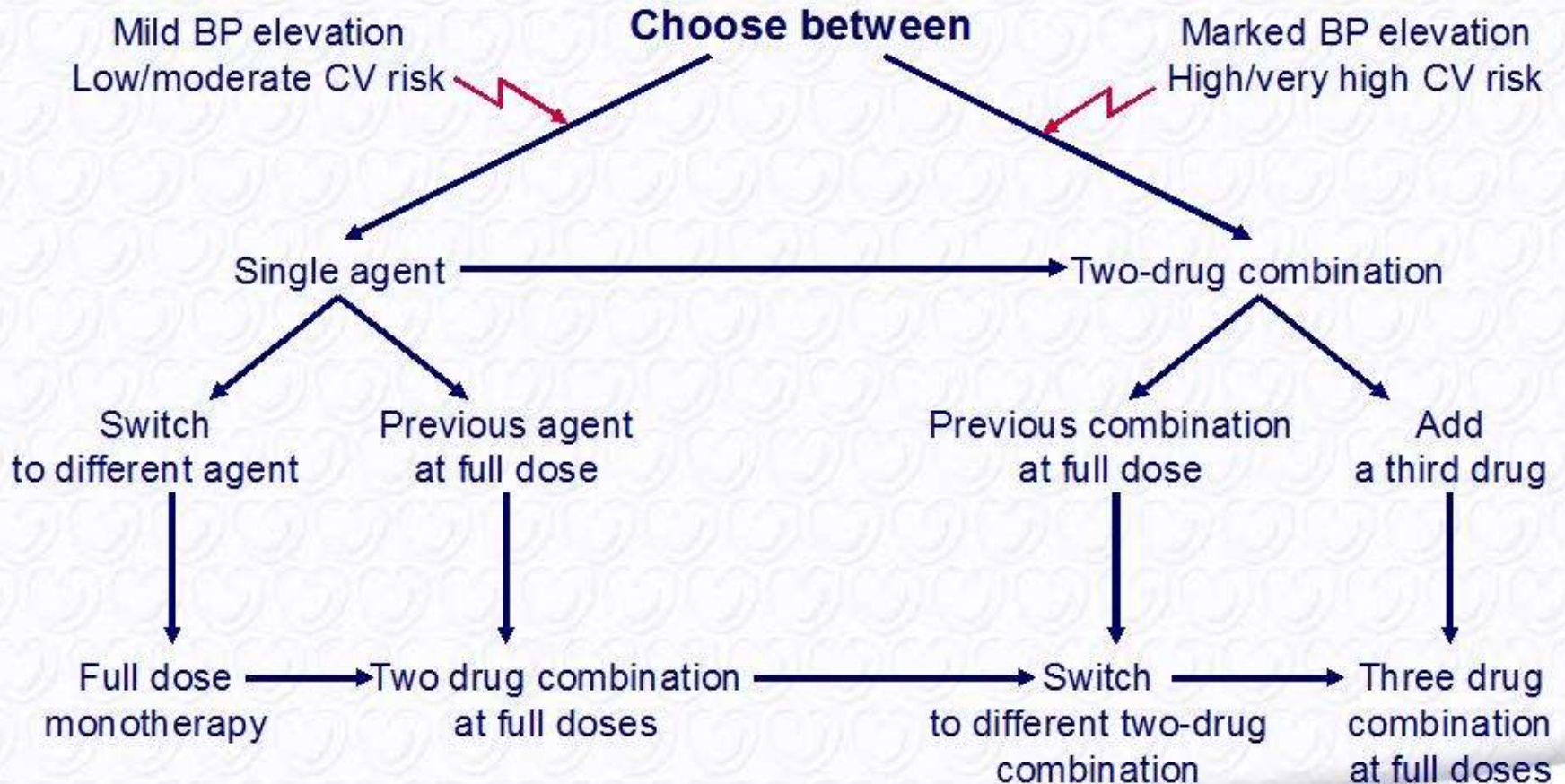
| <u>Group</u> | <u>BP Goal (mm Hg)</u>             |                            |              |
|--------------|------------------------------------|----------------------------|--------------|
|              | <u>General</u>                     | <u>DM*</u>                 | <u>CKD**</u> |
| JNC 8:       | <60 yr: <140/90<br>≥60 yr: <150/90 | < 140/90                   | < 140/90     |
| ESH/ESC:     | < 140/90                           | < 140/85                   | < 140/90     |
| Elderly      | 140-150/90<br>(<80 yr: SBP<140)    | (SBP < 130 if proteinuria) |              |
| ASH/ISH      | < 140/90<br>≥80 yr: <150/90        | < 140/90                   | < 140/90     |
| AHA/ACC      | < 140/90                           | < 140/90                   | < 140/90     |

\*ADA: < 140/80 or lower

\*\*KDIGO: ≤140/90 w/o albuminuria ≤130/80 if ≥30 mg/24hr

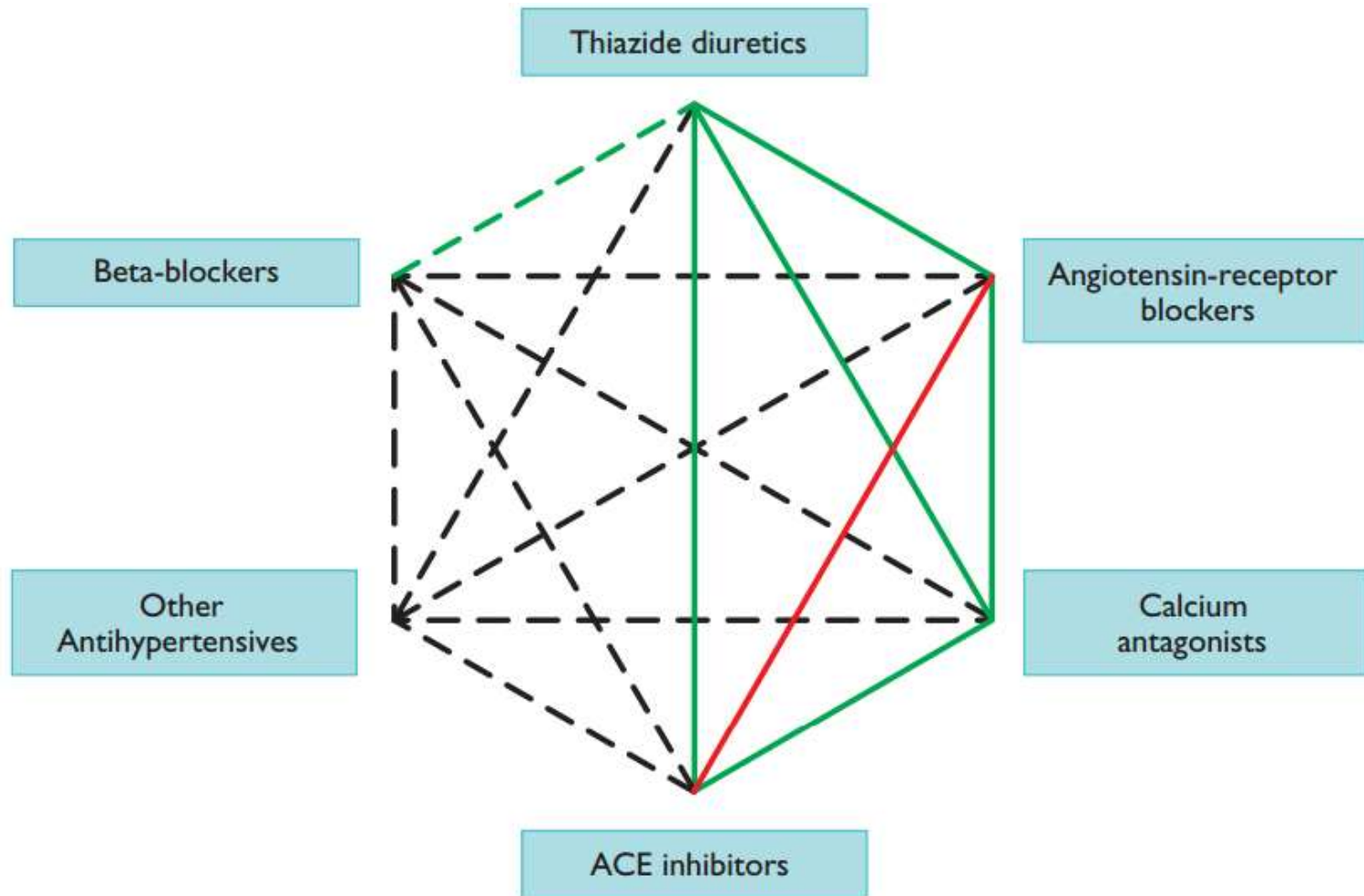
# Treatment

## (Monotherapy vs Drug Combination Therapy)



# Treatment

(Possible Combination of Antihypertensive Drugs' Classes)



ACE = angiotensin-converting enzyme.

# Prognosis

- Untreated HT is notorious for increasing the risk of mortality and is often described as a silent killer
- Mild to moderate HT, if left untreated, may be associated with a risk of atherosclerotic disease in 30% of people and organ damage in 50% of people within 8-10 years after onset
- Death from ischemic heart disease or stroke increases progressively as BP increases (for every 20 mm Hg systolic or 10 mm Hg diastolic increase in BP above 115/75 mm Hg, the mortality rate for both ischemic heart disease and stroke doubles)

# Prophylaxis

- Population strategies are required to reduce the consequences of high BP and reduce the need for antihypertensive drug therapy
- Lifestyle changes are recommended to lower BP, before starting drug therapy
- Effective lifestyle modification may lower blood pressure as much as an individual antihypertensive drug
- Combinations of two or more lifestyle modifications can achieve even better results

# Abbreviations

- ABP - ambulatory blood pressure
- ACE - angiotensin converting enzyme
- ARB - angiotensin receptor blocker
- AT - angiotensin
- BMI - body mass index
- BB - beta blockers
- BP - blood pressure
- CKD - chronic kidney disease
- CO - carbon oxide
- CV - cardiovascular
- DBP - diastolic blood pressure
- DM - diabetes mellitus
- ECG - electrocardiography
- GFR - glomerular filtration rate
- HDL-C –high density lipoprotein cholesterol
- HIC -high-income countries
- HT - arterial hypertension
- LDL-C – low density lipoprotein cholesterol
- LIC -low-income countries
- LMIC - lower middle-income countries
- LVH - left ventricle hypertrophy
- LVM - left ventricle mass
- NO - nitrogen oxide
- OD - organ demige
- RAAS – renin angiotensin aldosterone system
- RF - risk factors
- RCTs - randomized control trials
- SBP - systolic blood pressure
- TC - total cholesterol
- TG - triglycerides
- UMIC - upper middle-income countries



# Diagnostic and treatment guidelines

## Europe

- [2013 ESH/ESC Guidelines for the management of arterial hypertension](#)
- [Hypertension - National Institute for Health and Care Excellence \(nice\) guidelines and related materials](#)

## North America

- [2014 Evidence-based guideline for the management of high blood pressure in adults. Report from the panel members appointed to the eighth joint national committee \(JNC 8\)](#)
- [British Columbia guidelines on detection, diagnosis and management of hypertension \[2015\]](#)