

Cardiovascular Disease (II): Essential Hypertension

Biomedical Engineering - URJC

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February 13, 2025



Universidad
Rey Juan Carlos

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Introduction to Blood Pressure

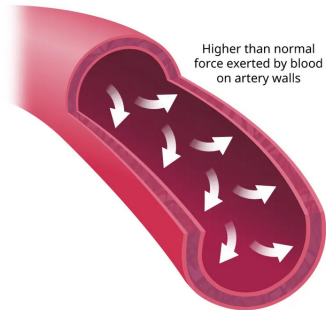
- Blood pressure is the **force** of circulating blood against vessel walls
- Cardinal vital sign guiding clinical decision-making

Key measurements

- Systolic pressure: Peak arterial pressure during systole
- Diastolic pressure: Minimum arterial pressure during diastole
- Mean arterial pressure: Calculated from systolic and diastolic

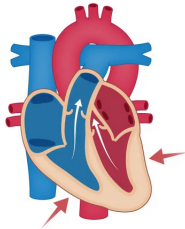
Blood Pressure

High Blood Pressure



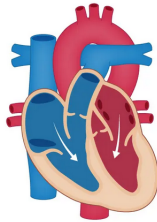
Systolic blood pressure

140 mmHg or higher



Diastolic blood pressure

90 mmHg or higher



Blood Pressure

Understand the significance of blood pressure measurements



Systolic Pressure

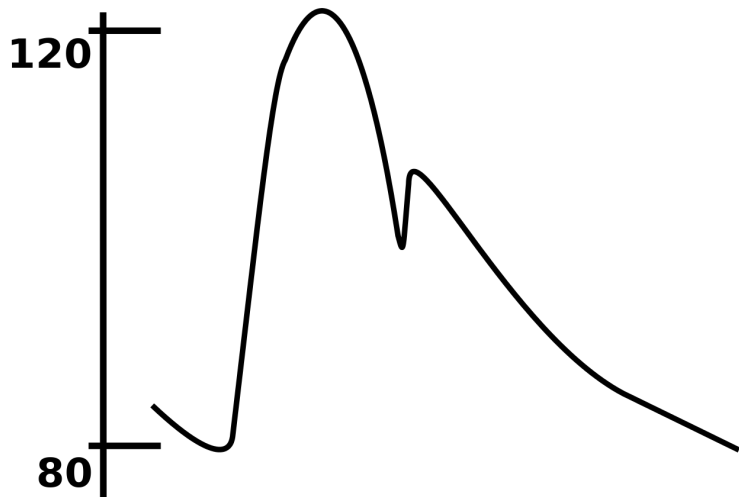
Indicates peak arterial pressure during heart contraction



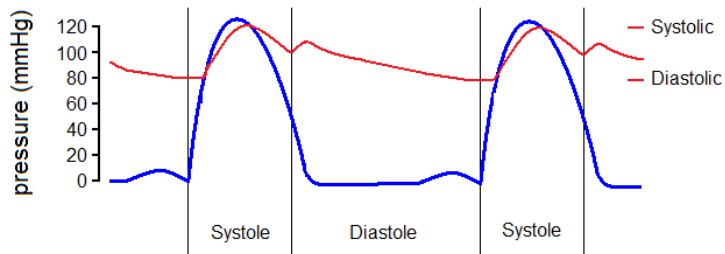
Diastolic Pressure

Indicates minimum arterial pressure during heart relaxation

Blood Pressure



Blood Pressure



Blood Pressure

Main determining factors

- Cardiac output
- Systemic vascular resistance
- Blood volume
- Arterial stiffness

Variable factors:

- Person's situation
- Emotional state
- Activity level
- Health/disease state

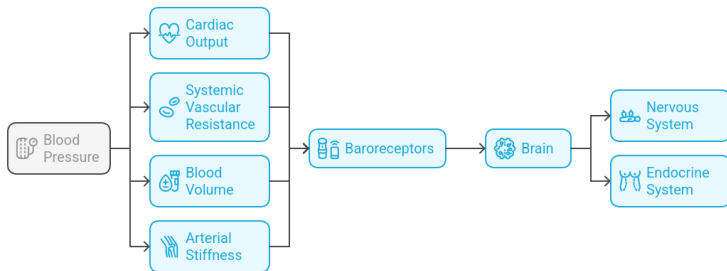
Short-term Regulation

Key Mechanisms

- Baroreceptors in carotid artery
- Brain-mediated responses
- Nervous system regulation
- Endocrine system involvement

Blood Pressure Regulation

Blood Pressure Regulation Flowchart

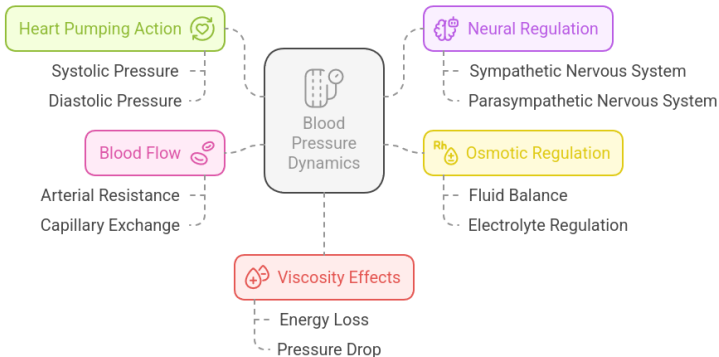


Physiology and Hemodynamics

- Blood pressure varies between systolic and diastolic during each heartbeat
- Primary driver: Pumping action of the heart
- Additional regulation:
 - Neural regulation (brain)
 - Osmotic regulation (kidney)
- Blood pressure decreases along circulation due to:
 - Viscosity effects
 - Resistance in small arteries and arterioles

Blood Pressure Regulation

Blood Pressure Dynamics and Regulation



Cardiac Output and Stroke Volume

Cardiac Output Components

Cardiac Output = Stroke Volume \times Heart Rate

Stroke Volume Influences

- 1 End-diastolic volume
- 2 Cardiac contractility
- 3 Afterload (circulatory resistance)

Vascular Resistance

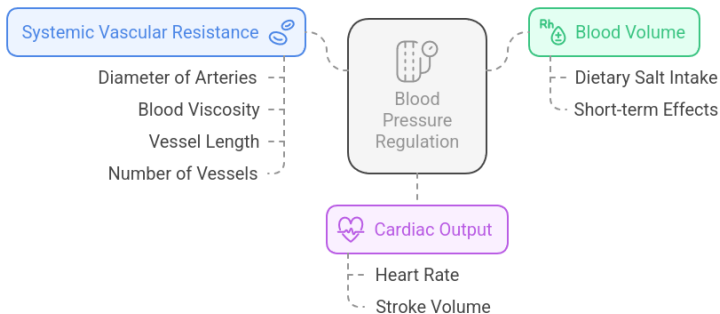
Hagen-Poiseuille's Relationship

$$\text{Resistance} \propto \frac{1}{\text{radius}^4}$$

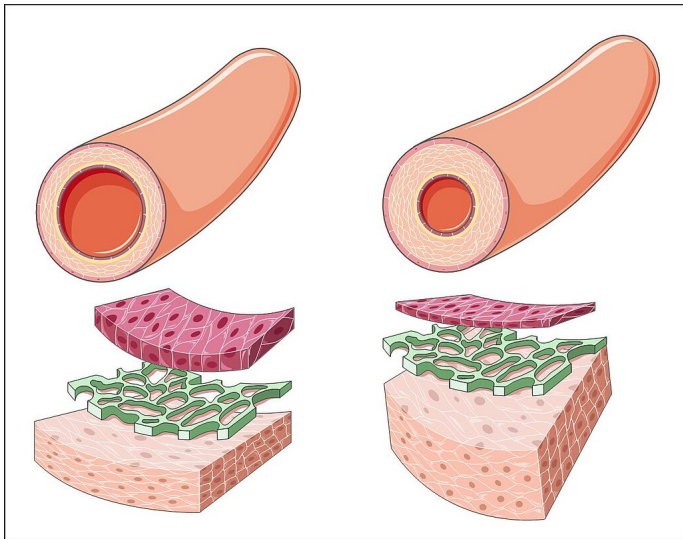
- Factors affecting resistance:
 - Vessel radius (**most important**)
 - Vessel length
 - Blood viscosity
 - Number of vessels
- Long-term changes through vascular **remodeling**

Blood Pressure Regulation

Blood Pressure Regulation: Factors and Relationships



Remodeling



Integrated Regulation

Multiple Control Systems

- Autonomic nervous system
- Baroreceptors
- Kidney function
- Complex interaction of all systems

Important Note

Individual responses can vary widely in both short and long term

Definition of Hypertension

Current Clinical Definition

- Systolic BP ≥ 130 mmHg and/or
- Diastolic BP ≥ 80 mmHg

Treatment Thresholds

- WHO definition: $\geq 140/90$ mmHg
- Therapeutic target: $\leq 130/80$ mmHg

Clinical Significance

Hypertension is a significant risk factor for:

- Stroke
- Myocardial infarction
- Heart failure
- Renal failure

Current management based on guidelines from:

- ACC (American College of Cardiology)
- ASH (American Society of Hypertension)
- ESC (European Society of Cardiology)
- ESH (European Society of Hypertension)

Etiology

Essential Hypertension

- Most cases are idiopathic (**essential hypertension**)
- Key risk factor: Increased salt intake

Salt Sensitivity

- 50-60% of patients are salt sensitive
- Genetic predisposition to salt response
- Direct correlation with hypertension development

Global Epidemiology

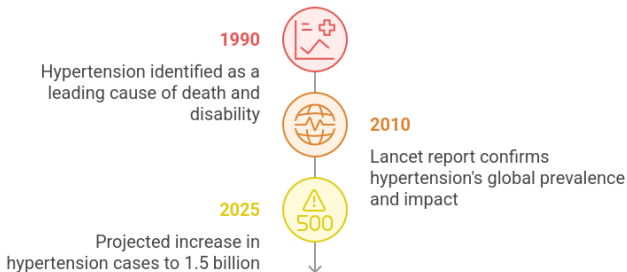
Current Statistics

- Over 1 billion adults affected worldwide
- Up to 45% of adult population affected
- 60% prevalence in population > 60 years

Future Projections

- Expected 15-20% increase
- Estimated 1.5 billion cases by 2025

The Global Impact of Hypertension: A Timeline



Public Health Impact

Global Health Survey (2010)

- Leading cause of death and disability-adjusted life years
- Consistent trend since 1990

Impact on Developed Countries

- Leading cause of cardiovascular disease-related deaths
- Second only to smoking as preventable cause of death

Pathophysiology

Key Mechanisms

- 1 Increased salt absorption
 - Results in volume expansion
- 2 Impaired RAAS response
 - Renin-Angiotensin-Aldosterone System dysfunction
- 3 Increased sympathetic activation
 - Enhanced nervous system response

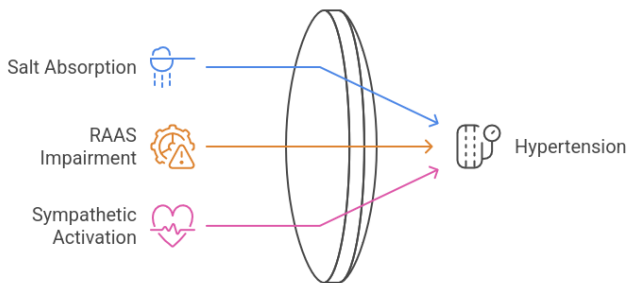
Physiological Consequences

Results in:

- Increased total peripheral resistance
- Increased afterload
- Development of hypertension

Pathophysiology

Mechanisms Leading to Hypertension



Clinical Presentation

Common Presentations

- Usually asymptomatic (incidental finding)
- May present with **end-organ damage** (in Spanish: *lesión de órgano diana*):
 - Stroke-like symptoms
 - Hypertensive encephalopathy
 - Chest pain
 - Shortness of breath
 - Acute pulmonary edema

Physical Examination

Key Elements to Assess (ONLY if secondary hypertension suspected)

- Coarctation of aorta and aortic valve disease
- Renovascular disease
- Polycystic kidneys
- Endocrine disorders
 - Hypercortisolism
 - Hyperthyroidism

Proper BP Measurement Technique

Key Requirements

- Patient seated quietly for ≥ 5 minutes
- Three measurements on two separate occasions
- 1-2 minutes between readings
- Record average of last two readings
- Cuff should cover 80% of arm circumference

Gold Standard

Ambulatory blood pressure measurement:

- Most accurate method
- Identifies masked hypertension
- Detects **white coat effect**

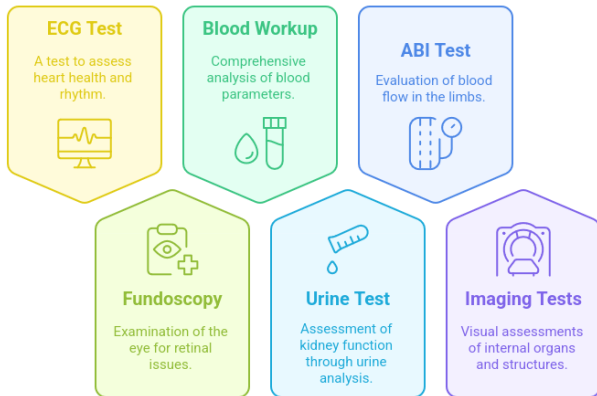
Clinical Evaluation

Essential Workup

- 12-lead ECG
- Fundoscopy (it checks the fundus of the eye –back of the inside of the eye, including the retina and optic nerve–)
- Blood tests:
 - Complete blood count
 - Renal function (creatinine, eGFR)
 - Electrolytes
 - Glucose profile, thyroid profile
 - Lipid profile
 - Uric acid
- Urine albumin:creatinine ratio
- Ankle-brachial index (if indicated)

Clinical Evaluation

Medical Tests



ACC Classification

Blood Pressure Categories

- Normal: $< 120/80$ mmHg
- Elevated: $120-129/< 80$ mmHg
- Stage 1: $130-139/80-89$ mmHg
- Stage 2: $\geq 140/90$ mmHg

White Coat Hypertension

Office BP $\geq 130/80$ but $< 160/100$ mmHg with:

- Normal ambulatory/home readings
- BP $\leq 130/80$ after 3 months of therapy

ESC/ESH Classification

Detailed Categories

- Optimal: $< 120/80$ mmHg
- Normal: 120-129/80-84 mmHg
- High normal: 130-139/85-89 mmHg
- Grade 1: 140-159/90-99 mmHg
- Grade 2: 160-179/100-109 mmHg
- Grade 3: $\geq 180/110$ mmHg

Management Approach

Non-pharmacological Management

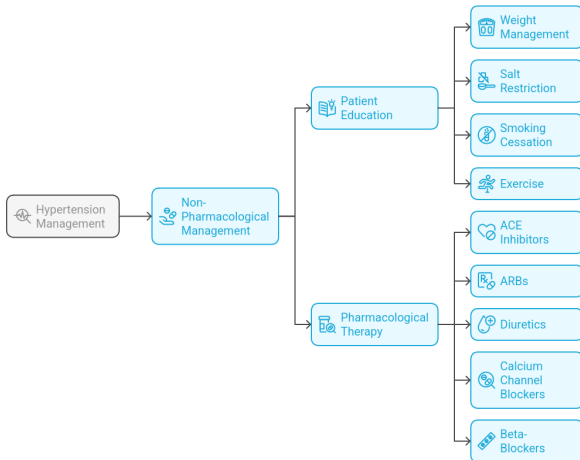
- Weight management (it reduces 5-20 mmHg SBP)
- Salt restriction
- Smoking cessation
- OSA management
- Regular exercise
- Patient education at every visit

Pharmacological Options

- ACE inhibitors
- Angiotensin receptor blockers
- Thiazide diuretics
- Calcium channel blockers
- Beta-blockers

Management Approach

Hypertension Management Flowchart



Complications

Major Complications

- Coronary heart disease
- Myocardial infarction
- Stroke (ischemic/hemorrhagic)
- Hypertensive encephalopathy
- Renal failure
- Peripheral arterial disease
- Atrial fibrillation
- Aortic aneurysm

Prognosis

Risk Factors

- CVD risk doubles with:
 - 20 mmHg \uparrow in SBP
 - 10 mmHg \uparrow in DBP
- Progressive disease nature
- Control determines outcome

Key Message –Long-term success requires:

- Sustained lifestyle modifications
- Regular monitoring
- Medication adherence
- Patient education