Cardiovascular Disease (II): Essential Hypertension

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February 13, 2025

Contents

1 Introduction

1.1 Blood pressure

Blood pressure is the pressure of circulating blood against the walls of blood vessels. Most of this pressure results from the heart pumping blood through the circulatory system. Blood pressure is a cardinal vital sign that guides acute and long-term clinical decision-making. Given its importance in directing care, measuring blood pressure accurately and consistently is essential.

In general, two values are recorded during the measurement of blood pressure. The first, systolic pressure, represents the peak arterial pressure during systole. The second, diastolic pressure, represents the minimum arterial pressure during diastole. Finally, a third value, mean arterial pressure, can be calculated from the systolic and diastolic pressures.

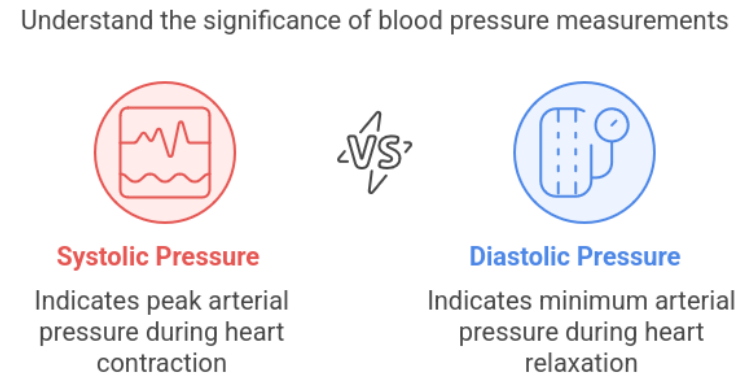

Figure 1: The four main entities included in cardiovascular disease.

Blood pressure is influenced by cardiac output, systemic vascular resistance, blood volume and arterial stiffness, and varies depending on person's situation, emotional state, activity and relative health or disease state. In the short term, for a fast control, blood pressure is regulated by baroreceptors in the carotid artery, which act via the brain to influence the nervous and the endocrine systems.

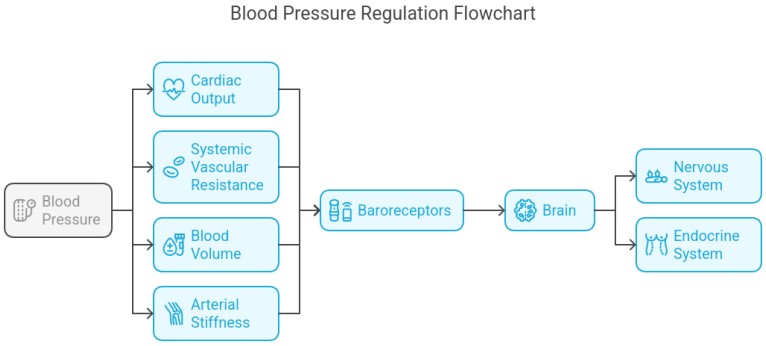

Figure 2: The four main entities included in cardiovascular disease.

1.1.1 Physiology and Hemodynamics

During each heartbeat, blood pressure varies between a maximum (systolic) and a minimum (diastolic) pressure. The blood pressure in the circulation is principally due to the pumping action of the heart. However, blood pressure is also regulated by neural regulation from the brain, as well as osmotic regulation from the kidney. Blood pressure allows to drive the flow of blood around the circulation. The blood flow depends on both blood pressure and the resistance to flow presented by the blood vessels. Blood pressure decreases as the circulating blood moves away from the heart through arteries and capillaries due to viscosity (viscosity makes flow to lose energy). Blood pressure drops over the whole circulation, although most of the fall occurs along the small arteries and arterioles (they are *pressure vessels*).

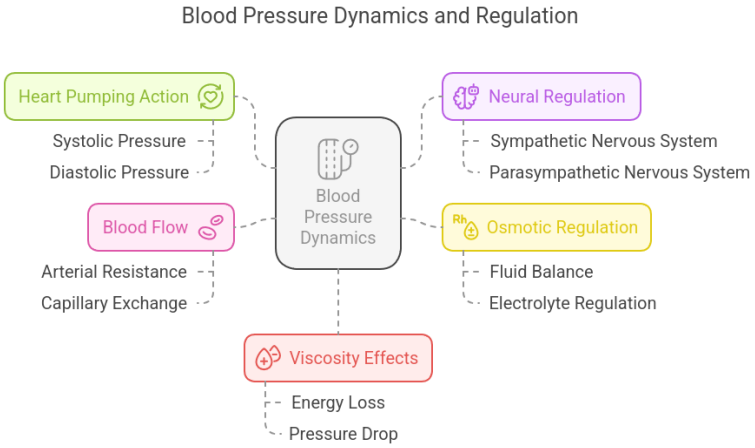

Figure 3: The four main entities included in cardiovascular disease.

Most influences on blood pressure can be understood in terms of their effect on cardiac output, systemic vascular resistance, or arterial stiffness. Cardiac output is the product of stroke volume and heart rate. Stroke volume is influenced by:

1. the end-diastolic volume;
2. cardiac contractility; and
3. afterload, the resistance to blood flow presented by the circulation.

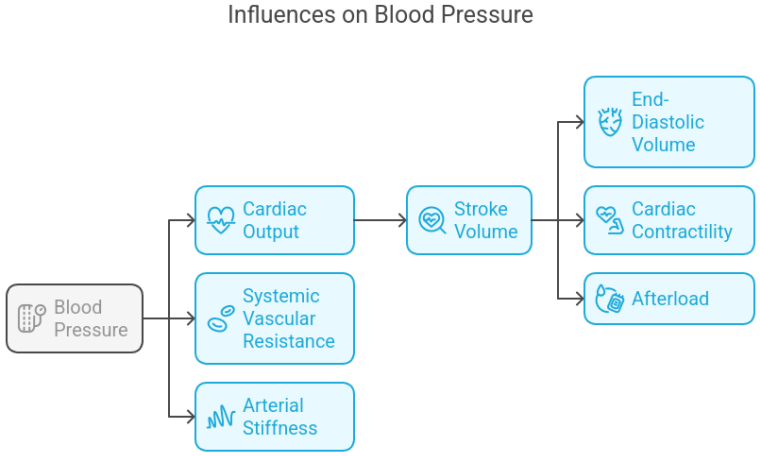

Figure 4: The four main entities included in cardiovascular disease.

In the short-term, the greater the blood volume, the higher the cardiac output. This has been proposed as an explanation of the relationship between high dietary salt intake and increased blood pressure. But in the longer-term the relationship between volume and blood pressure is more complex. In simple terms, systemic vascular resistance is mainly determined by the diameter (the lumen) of small arteries and arterioles. The resistance attributable to a blood vessel depends on its radius as described by the Hagen-Poiseuille's equation (resistance in inversely proportional to radius4). Hence, the smaller the radius,

the higher the resistance. Other physical factors that affect resistance include: vessel length (the longer the vessel, the higher the resistance), blood viscosity (the higher the viscosity, the higher the resistance) and the number of vessels, particularly the smaller numerous, arterioles and capillaries. However, the length of vessels, the viscosity and the number of arterioles rarely increase or decrease systemic blood pressure because its contribution to total systemic resistance is small.

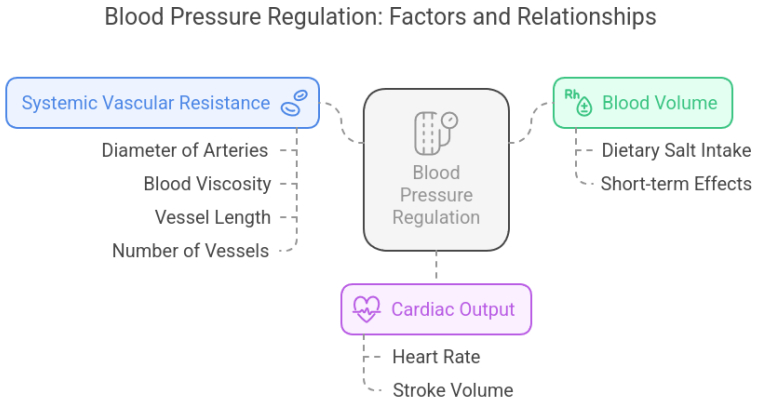

Figure 5: The four main entities included in cardiovascular disease.

Of note, it is worth noting that in the longer term a process termed **remodeling** can contribute to changing the caliber of small blood vessels and influencing resistance and reactivity to vasoactive agents.

In practice, autonomic nervous system, baroreceptors, kidney, and other systems regulate blood pressure, they respond to these factors, and are regulated by all these factors so that, although the above issues are important, they rarely act in isolation and the actual arterial pressure response of a given individual can vary widely in the short and long term.

1.1.2 Definition

The current definition of hypertension is systolic blood pressure (SBP) values of 130 mm Hg or more and/or diastolic blood pressure (DBP) of more than 80 mm Hg. Hypertension ranks among the most common chronic medical condition characterized by a persistent elevation in arterial pressure.

Hypertension has been among the most studied topics of the previous century and has been one of the most significant comorbidities contributing to the development of stroke, myocardial infarction, heart failure, and renal failure.

The definition and categories of hypertension have been evolving over the years, but there is a consensus that persistent BP readings of 140/90 mm Hg or more should undergo treatment with the usual therapeutic target of 130/80 mm Hg or less.

This manuscript will attempt to review the available knowledge and the recent updates and guidelines on hypertension put forward by major societies: American College of Cardiology (ACC), American Society of Hypertension (ASH), European Society of Cardiology (ESC) and European Society of Hypertension (ESH).

2 Etiology

Most cases of hypertension are idiopathic, which is also known as essential hypertension. It has long been suggested that an increase in salt intake increases the risk of developing hypertension. One of the described factors for the development of essential hypertension is the patient's genetic ability to salt response. About 50% to 60% of the patients are salt sensitive and therefore tend to develop hypertension.

3 Epidemiology

More than one billion adults worldwide have hypertension, with up to 45% of the adult populace being affected by the disease. The high prevalence of hypertension is consistent across all socio-economic and income strata, and the prevalence rises with age, accounting for up to 60% of the population above 60 years of age.

In the year 2010, the global health survey report published in Lancet, which was comprised of patient data from 67 countries, reported Hypertension as the leading cause of death and disability-adjusted life years worldwide since the year 1990.

In the United States, hypertension alone accounts for more cardiovascular disease-related deaths than any other modifiable risk factor and is second only to cigarette smoking as a preventable cause of death for any reason.

Recent estimates have suggested the number of patients with hypertension could increase as much as 15% to 20%, which could reach close to 1.5 billion by 2025.

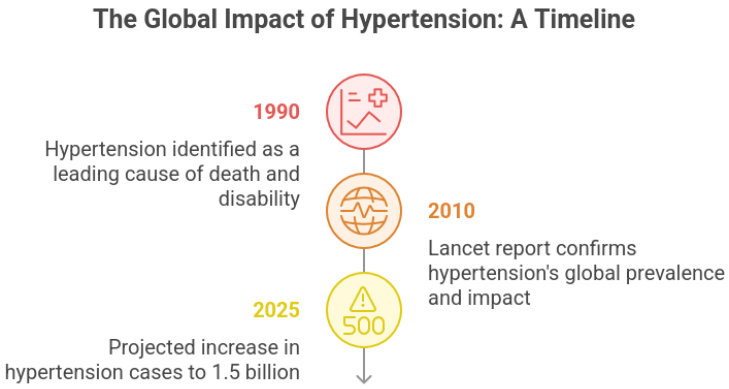

Figure 6: The four main entities included in cardiovascular disease.

4 Pathophysiology

There are various mechanisms described for the development of hypertension, which include increased salt absorption resulting in volume expansion, an impaired response of the renin-angiotensin-aldosterone system (RAAS), and increased activation of the sympathetic nervous system. These changes lead to the development of increased total peripheral resistance and increased afterload, which in turn leads to the development of hypertension.

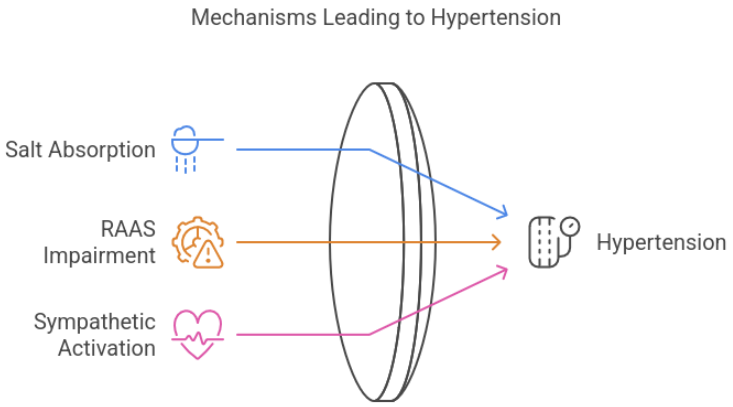

Figure 7: The four main entities included in cardiovascular disease.

5 History and Physical Examination

Most cases of hypertension are asymptomatic and are diagnosed incidentally on blood pressure recording or measurement.

Some cases present directly with symptoms of end-organ damage as stroke-like symptoms or hypertensive encephalopathy, chest pain, shortness of breath, and acute pulmonary edema.

Physical examination may be unyielding other than occasional edema in feet or raised blood pressure, but one needs to look for signs of:

- Coarctation of the aorta and aortic valve disease.
- Renovascular disease.
- Polycystic kidneys.
- Endocrine disorders such as hypercortisolism or hyperthyroidsm.

5.1 Evaluation

Blood pressure should be taken at least three office measurements on at least two separate occasions (at least 1 to 2 minutes apart) to diagnose hypertension. BP is then recorded as the average of the last two readings.

The patient should remain seated quietly for at least 5 minutes before taking the blood pressure, and proper technique is necessary. The blood pressure cuff should cover 80% of the arm circumference because larger or smaller pressure cuffs can falsely underestimate or overestimate blood pressure readings.

Ambulatory blood pressure measurement is the most accurate method to diagnose hypertension and also aids in identifying individuals with masked hypertension as well as the white coat effect.

Further evaluation regarding hypertension consists of looking for signs of end-organ damage and consists of the following:

- 12 lead ECG (to document left ventricular hypertrophy, cardiac rate, and rhythm)
- Fundoscopy to look for retinopathy/ maculopathy

- Blood workup including complete blood count, ESR, creatinine, eGFR, electrolytes, HbA1c, thyroid profile, blood cholesterol levels, and serum uric acid
- Urine albumin to creatinine ratio
- Ankle-brachial pressure index - ABI (if symptoms suggestive of peripheral arterial disease)
- Imaging including carotid Doppler ultrasound, echocardiography, and brain imaging (where clinically deemed feasible)

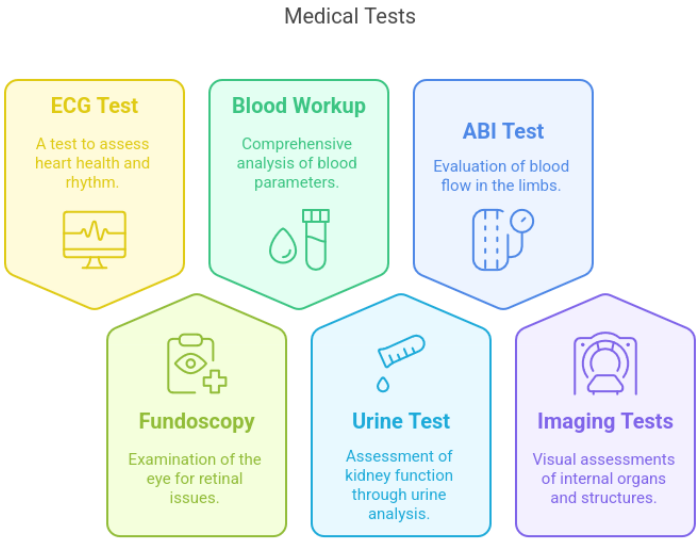

Figure 8: The four main entities included in cardiovascular disease.

5.2 Staging

Classification and stages of hypertension, as defined in recent American College of Cardiology (ACC) guidelines, are as under:

- Normal: SBP less than 120 and DBP less than 80 mm Hg;
- Elevated: SBP 120 to 129 and DBP less than 80 mm Hg;
- Stage 1 hypertension: SBP 130 to 139 or DBP 80 to 89 mm Hg;
- Stage 2 hypertension: SBP greater than or equal to 140 mm Hg or DBP greater than or equal to 90 mm Hg.

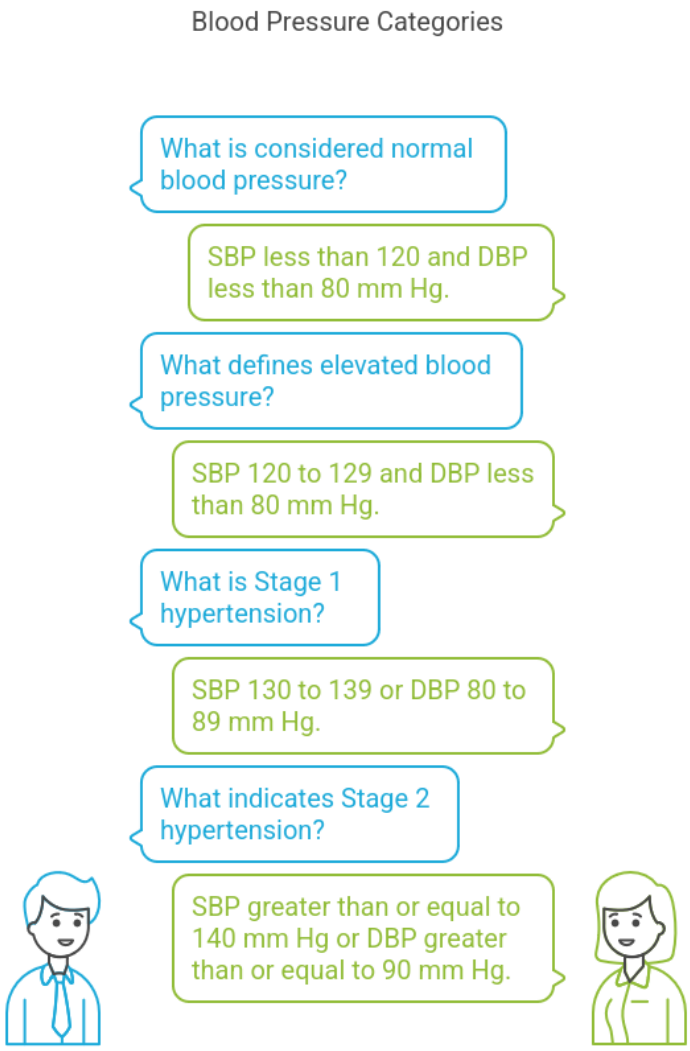

Figure 9: The four main entities included in cardiovascular disease.

White coat hypertension is an office BP of 130/80 mm Hg or more but less than 160/100 mm Hg, which comes down to 130/80 mm Hg or less after at least 3 months of anti-hypertensive therapy. Ambulatory or home blood pressure measurement is usually necessary for this diagnosis.

The recent ESC/ESH guidelines defined Hypertension as under:

- Optimal: SBP less than 120 mm Hg and DBP less than 80 mm Hg
- Normal: SBP 120 to 129 mm Hg and/or DBP 80 to 84 mm Hg
- High normal: SBP 130 to 139 mm Hg and/or DBP 85 to 89 mm Hg
- Grade 1 hypertension: SBP 140 to 159 mm Hg and/or DBP 90 to 99 mm Hg
- Grade 2 hypertension: SBP 160 to 179 mm Hg and/or DBP 100 to 109 mm Hg
- Grade 3 hypertension: SBP greater than or equal to 180 mm Hg and/or DBP greater than or equal to 110 mm Hg

- Isolated systolic hypertension: SBP greater than or equal to 140 mm Hg and DBP less than 90 mm Hg (further classified into Grades as per the above ranges of SBP)

6 Treatment / Management

The management of hypertension subdivides into pharmacological and non-pharmacological management.

Non-pharmacological and lifestyle management are recommended for all individuals with raised BPs regardless of age, gender, comorbidities, or cardiovascular risk status.

Patient education is paramount to effective management and should always include detailed instructions regarding weight management, salt restriction, smoking management, adequate management of obstructive sleep apnea, and exercise. Patients need to be informed and revised at every encounter that these changes are to be continued lifelong for effective disease treatment.

Weight reduction is advisable if obesity is present, although optimum BMI and optimal weight range are still unknown. Weight reduction alone can result in decreases of up to 5 to 20 mm Hg in systolic blood pressure.

Smoking may not have a direct effect on blood pressure but will help in reducing long-term sequelae if the patient quits smoking.

Lifestyle changes alone can account for up to a 15% reduction in all cardiovascular-related events.

Pharmacological therapy consists of angiotensin-converting enzyme inhibitors (ACEi), angiotensin receptor blockers (ARBs), diuretics (usually thiazides), calcium channel blockers (CCBs), and beta-blockers (Bbs).

The choice of treatments are instituted taking into account age, race and comorbidities (i.e., renal dysfunction, LV dysfunction, heart failure, or cerebrovascular disease).

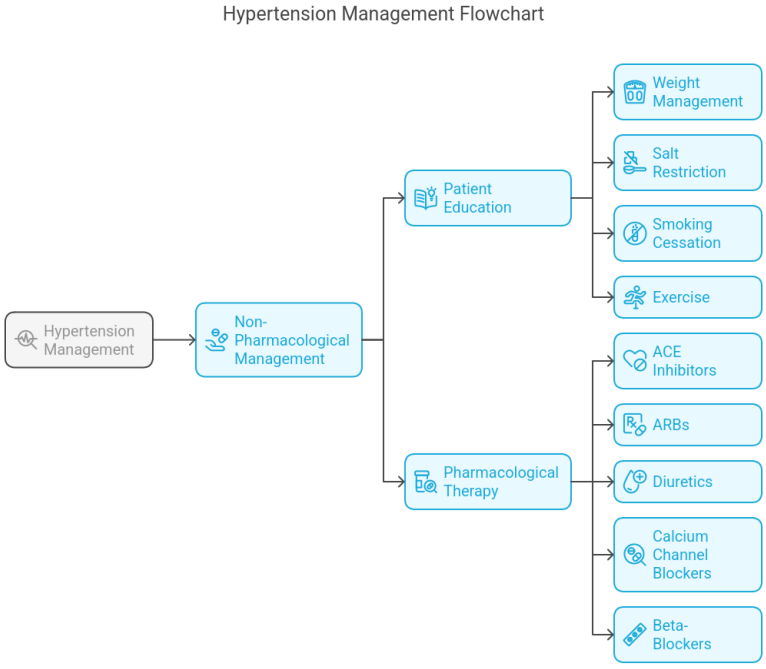

Figure 10: The four main entities included in cardiovascular disease.

6.1 Prognosis

Large-scale metanalyses have also shown the rising CVD and vascular disease risk with a rise in systolic and diastolic blood pressures, with almost doubling of the risk of death from heart disease and stroke with rising SBP of as much as 20 and DBP of 10 mm Hg.[15]

The prognosis depends on blood pressure control and is favorable only if the blood pressures attain adequate control; however, complications may develop in some patients as hypertension is a progressive disease.

Adequate control and lifestyle measures only serve to delay the development and progression of sequelae such as chronic kidney disease and renal failure.

6.2 Complications

The following complications have been reported with uncontrolled hypertension in multiple large-scale population trials.

- Coronary heart disease (CHD)
- Myocardial infarction (MI)
- Stroke (CVA), either ischemic or intracerebral hemorrhage
- Hypertensive encephalopathy
- Renal failure, acute versus chronic
- Peripheral arterial disease
- Atrial fibrillation
- Aortic aneurysm
- Death (usually due to coronary heart disease, vascular disease, or stroke-related)

7 Summary

Hypertension is a chronic disorder and requires long-term care and management. Detailed education regarding lifestyle modification and pharmacological therapy is the key to success for better control of blood pressure and to prevent complications. Weight management, physical activity, limiting alcohol/tobacco/smoking is a critical strategy to decrease cardiovascular risk.