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Hypertension: An Overview of Pathogenesis, Risk Factors, Complications, and Treatment Approaches

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ABSTRACT

Hypertension is a widespread chronic cardiovascular disorder and a major contributor to global morbidity and mortality. The condition affects more than one billion individuals worldwide, with a higher and increasing prevalence in low- and middle-income countries. Hypertension develops through complex interactions among genetic predisposition, lifestyle factors, metabolic disorders, and environmental influences. Key mechanisms involved in its pathogenesis include endothelial dysfunction, oxidative stress, vascular remodeling, and activation of the renin–angiotensin–aldosterone system, all of which contribute to persistent elevation of arterial blood pressure. Resistant hypertension, in which blood pressure remains uncontrolled despite multiple antihypertensive medications, presents an additional clinical challenge and increases the risk of cardiovascular complications. If not properly managed, hypertension can lead to severe outcomes such as stroke, coronary artery disease, heart failure, and kidney damage. Management strategies include both pharmacological therapies—such as diuretics, ACE inhibitors, calcium channel blockers, and beta-blockers—and non-pharmacological approaches including dietary modification, weight control, and regular physical activity. Recent advances in therapeutic approaches, including device-based treatments, provide new possibilities for managing resistant hypertension and improving patient outcomes.

Keywords: Endothelial dysfunction, Hypertension, Oxidative stress, Renin–angiotensin–aldosterone system (RAAS), Resistant hypertension

INTRODUCTION

A major clinical challenge is resistant hypertension (RH), affecting 10–15% of hypertensive patients characterized by blood pressure control resistance. These patients often have a prolonged history of hypertension and related conditions such as diabetes, obesity, and renal failure. Ambulatory blood pressure monitoring (ABPM) is essential for distinguishing between white-coat resistant hypertension (WCRH) and true resistant hypertensives, the latter showing poorer health outcomes and more co-morbidities. Recent advancements in device-based therapies highlight the need for better identification of suitable treatment candidates after traditional methods have failed. [(1)]

Globally, 31.1% of adults had a diagnosis of hypertension in 2010, with notable differences between high-income (28.5%) and low-to-middle-income (31.5%) nations. There were about 1.39 billion people with hypertension, 349 million of whom lived in high-income nations and 1.04 billion in low- and middle-income nations. In high-income nations, the prevalence of hypertension fell by 2.6% between 2000 and 2010, but in low- and middle-income areas, it increased by 7.7%. While awareness, treatment, and control all significantly improved in high-income nations, awareness and treatment only slightly increased and control slightly decreased in low- and middle-income nations. The study highlights the increasing disparities in hypertension around the world and the pressing need for cooperative efforts to address this health issue, particularly in developing countries. [(2)]

The goal is to compare the rates of type 2 diabetes and hypertension in urban slums with those in urban and rural areas. Method: Using data from Ovid MEDLINE, Cochrane CENTRAL, and EMBASE up until December 2020, a systematic review and meta-analysis based on studies with hypertension defined as blood pressure ≥140/90 mm Hg and type 2 diabetes prevalence was carried out. Results: The prevalence of type 2 diabetes and hypertension in slum populations varied from 0.9% to 25.0% and 4.2% to 52.5%, respectively, across 62 studies with 108,110 participants. It was discovered that slum dwellers had a 30% lower risk of hypertension than non-slum urban dwellers, but a 35% higher risk than rural residents. Limitations: General ability was restricted by a small

number of comparative studies. In conclusion, there are considerable regional and national differences in the prevalence of diabetes and hypertension. [3]

The Public Health Intervention Wheel (PHI Wheel) is a framework in public health nursing comprising three practice levels—community, systems, and individual/family—and 17 interventions. This article reviews the PHI Wheel's development and global implementation by public health nurses, referencing updates from its 2019 second edition. It emphasizes the framework's cultural significance through international case studies and its role in public health nursing education, advocating for ongoing evidence advancement to improve population health. [4]

CLASSIFICATION OF HYPERTENSION

Hypertension is characterized by systolic blood pressure over 140 mmHg or diastolic pressure above 90 mmHg, affecting 20% to 30% of adults, especially the elderly. Individuals normotensive at 55 have a 90% lifetime risk. The condition is more prevalent in African Americans, who have increased complication risks. Despite its significance for cardiovascular health, just 29% of those with hypertension receive treatment, and only 45% manage it effectively.[5]

PATHOPHYSIOLOGY OF HYPERTENSION

Hypertension, or high blood pressure, is a prevalent chronic condition marked by elevated arterial pressure, serving as a leading cause of cardiovascular disease and a significant public health concern. Its development is influenced by various factors, including genetics, diet, lifestyle, and coexisting medical conditions. Treatment encompasses both lifestyle adjustments—such as dietary changes and exercise—and pharmacological methods, utilizing medications like diuretics and ACE inhibitors. The condition is diagnosed via blood pressure measurements, categorized into stages such as prehypertension and hypertension. Effective management is essential to reduce its impact on global health, necessitating an understanding of its complex etiology. [6]

The renin-angiotensin-aldosterone system (RAAS) is essential for controlling vascular resistance, blood volume, and electrolyte balance. Through the baroreceptor reflex, it reacts to transient drops in arterial pressure and enables both acute and long-term adaptations. Renin, angiotensin II, and aldosterone are the three main constituents of the classical RAAS. They all function to raise arterial pressure in response to reduced renal perfusion, low salt delivery, and β-adrenergic stimulation. Although new components of RAAS have been discovered by recent research, the classical pathway is the main focus of this discussion. [7]

Because of oxidative stress and inflammation, which cause endothelial damage and vascular stiffness, hypertension raises the risk of serious cardiovascular issues. A year of 1 mg/day melatonin supplementation significantly decreased arterial stiffness ($p = 0.022$) in a study of 23 hypertensive patients; however, endothelial function did not significantly improve ($p = 0.688$). Furthermore, melatonin was linked to a significant decrease in total antioxidant capacity (TAC) levels ($p = 0.041$), indicating that it may improve arterial stiffness and lower TAC. [8]

RISK FACTOR

Kenya has a 24% prevalence of hypertension, which is a serious health risk worldwide, especially among young adults. A BMI of 25 or higher increases the risk of hypertension by 3.05 times, and a family history of hypertension almost triples the odds, according to a case-control study conducted at Tenwek Mission Hospital. There is a 70% lower risk for non-drinkers. These results show that young adults' hypertension is frequently disregarded, underscoring the necessity of focused preventive measures that address a range of risk factors. [9]

In the United States, 15–20% of ER visits are related to postpartum hypertension. 14.9% of 16,162 birthing patients in a 2017–2022 study had peripartum hypertension, and 9.1% required ED visits or readmissions. Maternal age ≥40, prenatal aspirin use, caesarean delivery, chronic hypertension, severe preeclampsia, postpartum haemorrhage, and intravenous antihypertensives were important risk factors. Antihypertensive medications and high blood pressure at discharge raised the likelihood of ED visits. Significant risk factors, including age ≥40, antihypertensive use, severe preeclampsia, and prior intravenous antihypertensives, were identified by logistic regression, underscoring the need for better predictive tools and interventions to lower postpartum hypertension-related visits and readmissions. [10]

High blood pressure has little impact on coronary heart disease (CHD) but increases the risk of cardiovascular disease (CVD), mainly through increased morbidity. Smoking and serum cholesterol levels are important lifestyle factors; smokers with treated hypertension have mortality rates that are two to three times higher. The presence of multiple risk factors reduces the effectiveness of antihypertensive treatments, and high cholesterol can independently increase the risk of CVD. [11]

In sub-Saharan Africa, hypertension is the primary cause of heart failure. According to a study, alcohol consumption and dipstick proteinuria are the next most important risk factors for hypertensive heart failure, after suboptimal medication adherence. A diet high in fruits and vegetables and the use of calcium channel blockers were protective factors. In order to increase medication adherence and encourage better eating habits, the study emphasises the significance of lifestyle modifications and public health campaigns. [(12)]

COMPLICATIONS OF HYPERTENSION

Clustered risk factors increase cardiovascular risk in obese hypertensive patients, requiring a comprehensive evaluation that goes beyond blood pressure. In this group, identifying additional risk factors and organ damage is crucial but difficult. Significant lifestyle modifications are necessary for management in order to lower blood pressure and weight. Certain medications, such as beta-blockers and diuretics, may increase the risk of developing new-onset diabetes, but current guidelines do not provide specific pharmacological treatments for these patients. Antihypertensive drugs that target the renin-angiotensin system are among the recommended treatments. Evaluation of obstructive sleep apnoea in resistant cases is also recommended due to lower treatment responses and possible need for multiple medications. [(13)]

This review examines the link between pulmonary hypertension and intravenous drug use, noting that the condition can stem from increased pulmonary vascular resistance or complications from heart and lung diseases. It discusses how HIV may contribute indirectly via the virus or treatments, and how intravenous drug use might lead to hepatitis C and portopulmonary hypertension. The review also addresses the worsening effects of interferon and sofosbuvir, potential direct pulmonary vascular injury caused by drugs, and complications like venous thromboembolism. A comprehensive understanding of a patient's intravenous drug use history is vital for accurate diagnosis and treatment. [(14)]

Untreated early-onset arterial hypertension raises the risk of cardiovascular disease. In order to identify high-risk individuals based on hypertension-mediated organ damage (HMOD), this study assessed 220 young patients (≤50 years) with systolic hypertension. A 50% prevalence of HMOD and notable increases in pulse wave velocity (19%) and carotid intima-media thickness (32%) are among the key findings. Systolic blood pressure burden was found to be significantly correlated with both left ventricular mass index and pulse wave velocity. The cardiovascular risk profile was higher in patients with two or more HMODs. According to the study's findings, certain HMODs, especially arterial stiffness, indicate a high-risk group of young hypertensives. [(15)]

PHARMACOLOGICAL MANAGEMENT

In the Philippines, the prevalence of hypertension increased from 22% in 1993 to 25.15% in 2013, making it a serious health concern. Only 27% of those afflicted are able to control their blood pressure, and many people are ignorant of their condition. Hypertension, which is defined as a blood pressure of 140/90 mm Hg or higher, mainly affects patients receiving monotherapy, which results in insufficient control rates. Stroke, ischaemic heart disease, chronic kidney disease, and hypertensive retinopathy are associated complications that affect financial resources. In accordance with global goals, the document examines management techniques and offers remedies to lessen the burden of hypertension. [(16)]

31.3% of adults in France between the ages of 18 and 74 had hypertension, according to a 2015 study. A single antihypertensive class was used by 57.7% of the 74.7% of aware hypertensives who received treatment. Remarkably, only 24.3% of patients had adequate blood pressure control, and 33.6% of patients adhered to their treatment. These results demonstrate the continued difficulties in successfully controlling hypertension in France and the need for improved clinical interventions. [(17)]

NON-PHARMACOLOGICAL MANAGEMENT

RECENT One common non-motor symptom of Parkinson's disease is orthostatic hypotension (OH), which can cause falls, syncope, and cognitive problems. Blood pressure readings taken in various positions are used to make the diagnosis and differentiate between neurogenic and non-neurogenic causes. Non-pharmacological techniques are the main focus of initial treatment, with medication being used if needed. Patients frequently experience issues like nocturnal and supine hypertension, which call for close observation. While untreated OH poses significant risks to day-to-day functioning, lifestyle modifications can reduce risks. Improving patient quality of life requires controlling both OH and supine hypertension. [(18)]

ADVANCES IN HYPERTENSION TREATMENT

Resistant hypertension (RH) is a severe form of hypertension a common chronic condition associated with an increased risk of cardiovascular death. Accurate determination is difficult because the prevalence of RH in hypertensive patients ranges from 6% to 18%. It is essential to comprehend the pathophysiology and treatment of RH, with an emphasis on determining the reasons behind

treatment resistance and using suitable diagnostic techniques. In order to improve outcomes for patients receiving subpar medical care, this review discusses both invasive procedures like arteriovenous anastomosis and novel therapies like renal denervation and carotid baroreceptor stimulation. [19]

Because of its complicated pathophysiology and related comorbidities, pulmonary hypertension is difficult to treat. According to recent research, recovering from COVID-19 may raise the chance of getting this illness. Anticoagulation, recombinant fusion proteins, stem cell therapy, and the potentially advantageous effects of SGLT2 inhibitors are examples of treatment advancements. In addition to discussing management techniques for associated conditions like sleep apnoea and interstitial lung disease, the article examines these treatment developments, especially in patients with a history of COVID-19. [20]

Pulmonary hypertension results from a variety of diseases characterized by persistent pulmonary vasoconstriction and irreversible vascular remodeling, negatively affecting patient prognosis. It may result in right ventricular failure if prompt action is not taken. Recently, nebulized inhalation therapy has emerged as a promising treatment option, utilizing inhaled vasodilators (such as sildenafil), anti-inflammatory agents (like simvastatin), and anti-peroxides (e.g., levocetirizine). This article reviews recent advances in these therapies to improve treatment options, enhance patient survival quality, alleviate symptoms, and improve prognoses for those affected by pulmonary hypertension. [21]

CONCLUSION

Hypertension remains a major public health issue due to its high prevalence and association with serious cardiovascular complications. The disease results from multiple physiological and lifestyle-related factors that contribute to sustained elevation of blood pressure. Early diagnosis, appropriate pharmacological treatment, and lifestyle modifications are essential for effective management and prevention of complications. Improving awareness, treatment adherence, and preventive strategies is crucial to reduce the burden of hypertension. Furthermore, emerging therapies and innovative treatment approaches may provide improved management options, particularly for patients with resistant hypertension.

Conflict of Interest

The authors declare that there is no conflict of interest regarding the publication of this manuscript.

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Ethical Approval

This article is a review-based study and does not involve any human or animal subjects; therefore, ethical approval was not required.

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