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HYPERTENSIVE DISEASE AS A PRIMARY RISK FACTOR FOR STROKE

Pulatova Sh. B.
Musaeva Yu. A.
Tavmuradova M. G.
Tashkent Medical Academy, Tashkent, Uzbekistan

Abstract
This article focuses on hypertensive disease as a primary risk factor for stroke, contributing to mortality and disability in the population. It describes the mechanisms by which elevated blood pressure affects the vascular system and the impact of this condition on stroke status. Current statistical data are discussed, as well as methods for monitoring and managing hypertension for prevention and counseling.

Keywords: Hypertensive disease, stroke, arterial hypertension.

Introduction

Hypertensive disease (HD) and stroke are among the leading conditions that result in significant health consequences for the population. HD and stroke are the most common diseases in modern cardiology and neurology, affecting public health and vulnerable countries. According to the World Health Organization (WHO), HD affects more than 1.13 billion people worldwide, accounting for approximately 30% of the adult population. Recent data indicate that hypertension is a major risk factor for a range of vascular diseases, including strokes. To date, stroke ranks as the second leading cause of mortality and the third leading cause of disability globally [2].

Stroke, in turn, is one of the leading causes of disability and death, particularly in low- and middle-income countries. In 2019, stroke accounted for more than 12.2 million new cases and 6.5 million deaths worldwide [3.4]. Stroke can be ischemic, where blood supply to the brain is disrupted due to thrombosis or atherosclerotic changes in the vessels, or hemorrhagic, where a blood vessel ruptures, leading to bleeding in the brain. Both types of stroke are significantly exacerbated by hypertension, as elevated blood pressure increases the risk of these events [1.7].

According to research, Arterial Hypertension (AH) significantly increases the risk of both transient ischemic attacks (TIAs) and full-blown strokes. TIAs, in turn, serve as precursors to strokes, often indicating the development of vascular disturbances in the brain that can lead to more severe consequences. It is important to note that AH reduces the elasticity of blood vessels, contributing to their damage, increased permeability, and thrombus formation, all of which are directly related to the development of stroke. Mechanisms associated with vascular wall damage are crucial pathogenic factors in the occurrence of stroke in patients with hypertension [10].

Arterial hypertension leads to changes in cerebral microcirculation, increasing blood viscosity and disrupting blood flow in small arteries, which promotes ischemia and thrombus formation. These processes can result in impaired cerebral circulation, subsequently causing a stroke.

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Furthermore, high blood pressure increases the likelihood of damage to cerebral vessels and the occurrence of aneurysms, which can lead to hemorrhagic stroke. Numerous studies indicate that over 50% of stroke patients have a history of hypertension, highlighting the strong correlation between these two conditions [2]. Patients with AH often suffer from other comorbidities, such as diabetes mellitus, atherosclerosis, and heart disease. This comorbidity further enhances the likelihood of stroke development, necessitating a comprehensive approach to treatment. It is essential to consider all risk factors, such as age, gender, heredity, cholesterol levels, and, of course, smoking and obesity [1].

HD is a primary risk factor for the development of stroke, which is associated with the prolonged exposure of elevated arterial pressure on the vascular wall, hemodynamic disturbances, and changes in microcirculation. Stroke, as an acute cerebrovascular accident, can be ischemic or hemorrhagic, and in both cases, hypertension plays a crucial role in its development.

Mechanisms of vascular wall damage in hypertension. In hypertensive disease, chronic elevation of arterial pressure leads to increased mechanical stress on the vascular walls. Initially, this may cause adaptive thickening (hypertrophy) of the vessels, allowing them to partially compensate for the effects of elevated pressure. However, over time, in the absence of effective therapy, vascular wall hypertrophy becomes pathological, increasing vessel stiffness and compromising their integrity. This, in turn, permits the following pathophysiological changes: atherosclerosis, which is a component of the pathogenesis of stroke in hypertensive disease, arises from chronic vascular wall damage, promoting the accumulation of lipids, cells, and fibrin in the arterial walls. This leads to the formation of atherosclerotic plaques, which can significantly narrow the vessel lumen and disrupt circulation [8].

Mechanical stress on the vessels.

Constant stress. In HD, arterial pressure remains elevated for prolonged periods. This creates a constant load on the vascular system, which must withstand this pressure. Under normal conditions, blood vessels, such as arteries, adapt to changes in pressure through their elasticity, dilation, and constriction. However, at persistently high pressure levels, vessels cannot fully recover and function as described above, leading to the following changes: a) thickening of the vascular wall. To cope with the elevated pressure, arterial walls become thicker and more resilient. This phenomenon is caused by vascular remodeling. Increased vessel stiffness impairs their ability to expand and contract normally, leading to hemorrhage and potential damage to organs supplied by this blood, such as the heart and brain; b) decreased elasticity of the vessels. Elevated pressure over time destroys elastic fibers in the vessel walls, reducing their ability to adapt to changes in blood pressure. This results in diminished vessel flexibility, further increasing pressure and worsening organ perfusion.

2. Stretching of the vascular wall: When arterial pressure remains consistently elevated, the walls of the vessels begin to stretch. This mechanism illustrates how hypertension affects the vessels. In particular, increased pressure leads to:

- Degenerative changes in the vascular wall. Prolonged exposure results in damage to the inner lining of the blood vessels—the endothelium. This layer plays a crucial role in maintaining

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normal circulation, including regulating vascular tone and preventing excessive contraction. Damaged endothelium can lead to the loss of its functions, promoting the development of atherosclerosis (the formation of plaques in the vessels) and other vascular diseases.

- Ruptures and micro-ruptures. In cases of chronically high pressure, the vascular wall becomes more susceptible to ruptures. This may lead to the formation of aneurysms (localized dilations of the vessels), which can rupture, causing dangerous conditions such as strokes or internal bleeding.
- Increased vascular permeability. Elevated pressure can also disrupt the barrier function of the vascular wall, increasing permeability to various molecules.
- Changes in microcirculation. High pressure also affects the smallest vessels—capillaries. As their condition deteriorates, blood supply to tissues and organs worsens, potentially leading to chronic diseases and damage, such as impaired kidney, heart, and brain functions.

3. Consequences of mechanical stress on the vessels:

- Atherosclerosis. Increased pressure contributes to endothelial damage and the formation of atherosclerotic plaques. These plaques can disrupt normal circulation, hindering the delivery of blood, oxygen, and nutrients to organs and tissues.
- Increased risk of stroke and myocardial infarction. Vascular changes caused by elevated pressure raise the risk of thrombosis. Thrombi can occlude vessels, disrupting circulation in the brain or heart.
- Impaired organ function. Due to chronic high pressure, vessels become less capable of supplying blood to vital organs, leading to their damage. For example, this can result in chronic kidney failure, heart failure, and vision impairment.

The role of turbulent flow. In hypertension, flow velocity increases, and turbulence occurs, especially in smaller and more branched vessels, where the flow changes direction. Turbulent flow creates additional fluctuations and pulsations against the vascular wall, exacerbating mechanical damage.

Microangiopathy is the damage to small blood vessels, such as arterioles and capillaries, due to prolonged exposure to high blood pressure. This process plays a key role in the pathogenesis of both ischemic and hemorrhagic strokes, particularly in cases of hypertension. Damage to the inner walls of blood vessels can lead to various consequences [9].

Pathogenesis of Stroke in Hypertension. Hypertension is one of the main risk factors for stroke, influencing the pathogenesis of both ischemic and hemorrhagic strokes. The development of stroke in the context of hypertension is associated with several mechanisms affecting both large and small blood vessels in the brain. These changes can lead to vascular wall damage, impaired blood flow, and ultimately, stroke.

1. Microvascular Changes in Hypertension. Prolonged high blood pressure causes microvascular changes in the brain, playing a crucial role in stroke development. Increased pressure forces the vascular wall to thicken under mechanical stress, reducing its elasticity. This leads to impaired blood flow in small arteries and capillaries, which can cause ischemia, particularly in brain areas sensitive to oxygen deficiency. Hypertension also increases the likelihood of atherosclerotic changes. Chronic pressure elevation damages the endothelial cells of blood vessels, contributing to the development of atherosclerosis and plaque formation,

which can narrow the lumen of blood vessels. These plaques can cause ischemic strokes by blocking the blood supply to specific areas of the brain. Additionally, atherosclerotic plaques can impair the normal functioning of blood vessels, increasing the risk of their rupture, which may lead to hemorrhagic stroke.

2. Impact on Large Blood Vessels. High blood pressure affects not only small blood vessels but also large vessels in the brain. Aneurysms caused by hypertension may rupture, leading to a hemorrhagic stroke. Chronic pressure increases the risk of vessel wall rupture, as it raises the tension on the vessel wall and diminishes its ability to withstand internal pressure.

3. Risk of Hypertensive crisis. One of the acute manifestations of hypertension is a hypertensive crisis, characterized by a sudden and significant increase in blood pressure, accompanied by impaired cerebral circulation. This condition can lead to vascular catastrophes, including stroke. Hypertensive crises can provoke the rupture of blood vessels in the brain or trigger thrombosis, increasing the risk of stroke. Hypertensive crises are especially dangerous when occurring in the context of long-standing hypertension, as the blood vessels are already weakened and altered.

4. Neurological Consequences of Hypertension. Elevated blood pressure affects not only blood vessels but also neurons in the brain. Chronic impairment of blood flow and oxygen deficiency lead to functional and structural neuronal damage. This can cause microstrokes, which may go unnoticed but leave serious neurological consequences such as cognitive disturbances, memory problems, and changes in the patient's psycho-emotional state.

5. Activation of Inflammatory and Hemostatic processes. In addition to mechanical damage to blood vessels, hypertension activates inflammatory processes in the vascular wall. Increased pressure activates endothelial cells that release pro-inflammatory molecules. These molecules promote platelet aggregation and thrombus formation, which increases the risk of ischemic stroke. Elevated pressure also enhances the activation of the hemostatic system, which can lead to excessive thrombus formation, including in the cerebral vessels.

6. Pathophysiology of Stroke in Hypertension. Depending on the type of stroke, hypertension has different effects on the brain. In the case of ischemic stroke, increased pressure promotes thrombosis and vessel blockage, disrupting blood supply to a specific area of the brain. In hemorrhagic stroke, hypertension causes the rupture of blood vessels, leading to brain hemorrhage and its damage.

Current research underscores the importance of blood pressure control in preventing stroke, especially in the population of individuals with hypertension. The mechanisms underlying vascular changes in hypertension provide opportunities for the development of more effective methods for stroke treatment and prevention. In particular, antihypertensive therapy aimed at lowering blood pressure reduces the risk of both ischemic and hemorrhagic strokes, as confirmed by clinical studies [5].

One of the key aspects of stroke prevention is appropriate and timely treatment of arterial hypertension. Numerous studies have shown that antihypertensive medications play a crucial role in reducing stroke risk in patients with hypertension. Specifically, the use of angiotensin-converting enzyme (ACE) inhibitors, angiotensin II receptor blockers (ARBs), diuretics, and beta-blockers helps lower blood pressure and, consequently, the risk of stroke [5]. Additionally,

controlling blood pressure fluctuations throughout the day is important for stroke prevention. Research shows that blood pressure variability can be an independent risk factor for stroke, emphasizing the importance of stabilizing blood pressure in hypertensive patients [7]. Medication aimed at reducing blood pressure variability has shown effectiveness in preventing strokes. Lifestyle modification, including weight loss, reduced salt intake, increased physical activity, smoking cessation, adherence to dietary recommendations, and relaxation, also plays a key role in prevention [9].

Developing effective methods for preventing and treating hypertension remains a crucial factor in reducing the risk of stroke and other cardiovascular diseases. According to research conducted as part of the Framingham Heart Study, controlling blood pressure in the early stages of hypertension significantly reduces the likelihood of stroke development [11-13].

Thus, arterial hypertension is a primary risk factor for stroke, and blood pressure control is a key element in preventing this dangerous condition. Hypertension treatment should be comprehensive, aimed at lowering blood pressure and preventing complications. Regular monitoring of the patient's condition is essential to adjust therapy promptly and prevent the development of stroke.

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