

Metabolic and Vascular Aspects on the Background of Arterial Hypertension and Diabetes Mellitus

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Abstract: Arterial hypertension (AH) and diabetes mellitus (DM) are interrelated conditions that often accompany each other and significantly increase the risk of cardiovascular diseases. Metabolic disorders such as insulin resistance, hyperglycemia and dyslipidemia play a key role in the pathogenesis of both conditions. These metabolic changes contribute to the development of endothelial dysfunction, increased vascular stiffness and remodeling of the vascular wall, which aggravates the course of hypertension and diabetes. Understanding these relationships is important for developing effective prevention and treatment strategies aimed at reducing cardiovascular risk in patients with a combination of hypertension and diabetes.

Keywords: Metabolic syndrome, arterial hypertension, diabetes mellitus, endothelium, dyslipidemia.

Introduction. Arterial hypertension (AH) and diabetes mellitus (DM) are among the most common chronic diseases affecting the cardiovascular system. According to the World Health Organization (WHO) and the International Diabetes Federation (IDF), the combination of these diseases increases the risk of myocardial infarction, stroke, chronic kidney disease, and heart failure [1]. According to epidemiological studies, hypertension occurs in 60-80% of patients with type 2 diabetes.

In patients with type 1 diabetes mellitus, arterial hypertension is not as common as in healthy people (in 20-40% of cases). However, with the development of diabetic nephropathy, the likelihood of hypertension increases. People with metabolic syndrome, prediabetes, and insulin resistance have a higher risk of developing hypertension than other people. According to the US National Institutes of Health (NIH), people with diabetes are twice as likely to develop hypertension as those without it [18].

Pathophysiological mechanisms underlying comorbidity include insulin resistance, endothelial dysfunction, chronic inflammation, RAAS hyperactivation, and lipid metabolism disorders. These factors contribute to the accelerated development of atherosclerosis and damage to target organs. Studying the mechanisms of hypertension development in DM, risk factors, and modern methods of prevention and treatment is an urgent task aimed at reducing cardiovascular morbidity and mortality in this category of patients [2].

Factors influencing the prevalence of hypertension in patients with diabetes.

Age – the frequency of the combination of diabetes and hypertension increases significantly with age, especially after 50 years.

Gender – women with diabetes after menopause have a higher risk of hypertension than men, which is associated with changes in hormonal levels.

Obesity is one of the key risk factors for the development of both diabetes and hypertension.

Genetic predisposition – the presence of hypertension and diabetes in a family history increases the likelihood of their combined course.

Lifestyle - inactivity, unbalanced diet, excess salt in the diet and chronic stress contribute to the development of hypertension in patients with diabetes.

An increase in the incidence of diabetes and hypertension is observed throughout the world and is associated with urbanization, changes in lifestyle, increasing life expectancy and the spread of obesity[11]. In developed countries, active programs for screening and controlling blood pressure in patients with diabetes help reduce the risk of complications, while in low-income countries the problem of comorbidity remains poorly controlled[17,18].

The endothelium is the inner lining of blood vessels, playing a key role in the regulation of vascular tone, permeability and inflammatory processes. Impairment of its function, known as endothelial dysfunction (ED), is one of the leading pathogenetic mechanisms linking arterial hypertension (AH) and diabetes mellitus (DM). The main functions of the endothelium in the regulation of vascular tone. Nitric oxide (NO) is a powerful vasodilator that reduces vascular resistance. Prostaglandins (PGI₂) have anti-aggregation and vasodilator properties[7]. Endothelin-1 (ET-1) is a strong vasoconstrictor involved in the regulation of blood pressure. Maintaining a balance between vasodilation and vasoconstriction. Regulation of inflammatory reactions and blood clotting[2].

Mechanisms of endothelial dysfunction in hypertension and diabetes. Reduced NO production. Insulin resistance and hyperglycemia reduce endothelial NO synthase (eNOS) activity, leading to insufficient vasodilation[2]. Increased oxidative stress promotes NO inactivation. Increased expression of endothelin-1 (ET-1). Increased vasoconstriction and inflammation[1].

Promotes vascular remodeling and progression of hypertension. Oxidative stress and inflammation. Increased production of reactive oxygen species (ROS) damages the endothelium. Proinflammatory cytokines (IL-6, TNF- α) are activated, enhancing vascular dysfunction. Protein glycation and dysfunction of endothelial cells. End products glycation enzymes (AGEs) damage endothelial cells, promoting the development of atherosclerosis[4].

Endothelial dysfunction plays a key role in the pathogenesis of hypertension and diabetes, so its correction is an important strategy in the prevention of cardiovascular diseases. Water and electrolyte balance plays a key role in the regulation of blood pressure (BP). Patients with arterial hypertension (AH) and diabetes mellitus (DM) experience significant changes in the metabolism of sodium, potassium and water, aggravated by hyperactivity of the renin-angiotensin-aldosterone system (RAAS)[1].

Main mechanisms of disorders: Hyponatremia and water retention - insulin resistance reduces renal sodium excretion, promoting volume-dependent hypertension. Hypokalemia - increased aldosterone activity promotes potassium loss, which impairs endothelial function. Hyperactivity of the RAAS - leads to chronic vascular spasm, inflammation and progression of hypertension[7].

Chronic hyperglycemia in diabetes causes systemic inflammation and vascular changes that contribute to the development of hypertension. Main mechanisms: Oxidative stress - excessive formation of free radicals damages the endothelium, reducing the production of vasodilators. Increased expression of pro-inflammatory cytokines (IL-6, TNF- α , CRP) - enhances chronic vascular inflammation[4].

Glycation of vascular wall proteins leads to thickening of blood vessels and their rigidity. Fibrosis and vascular remodeling accelerates the progression of hypertension and the development of cardiovascular complications. Thus, the combination of hyperglycemia, activation of the RAAS and water-electrolyte disorders forms a vicious circle that contributes to the development and worsening of hypertension in patients with diabetes. Elevated blood glucose levels, characteristic of diabetes, have a negative effect on blood vessels[4]. Hyperglycemia contributes to damage to the endothelium - the inner layer of blood vessels, which leads to disruption of their function and increased permeability.

Reduced vascular elasticity: excess glucose in the blood helps to reduce the elasticity of the vascular wall, which leads to increased blood pressure[2].

Activation of the RAAS: Hyperglycemia can activate the renin-angiotensin-aldosterone system (RAAS), which plays a key role in the regulation of blood pressure. Activation of the RAAS leads to vasoconstriction and fluid retention in the body, which contributes to increased blood pressure[4].

Hyperglycemia can contribute to the development of insulin resistance, a condition in which the body's cells become less sensitive to insulin. Insulin resistance can also contribute to high blood pressure. Lipid metabolism disorders, which are common in diabetes mellitus, also play an important role in the development of arterial hypertension.

Atherosclerosis: Dyslipidemia is characterized by increased levels of "bad" cholesterol (low-density lipoprotein - LDL) and triglycerides, as well as a decrease in the level of "good" cholesterol (high-density lipoprotein - HDL). These changes contribute to the development of atherosclerosis - the formation of plaques on the walls of blood vessels, which leads to their narrowing and increased blood pressure[4].

Inflammation: Dyslipidemia can contribute to the development of inflammation in the vascular wall, which also plays a role in the development of hypertension[2]. Hyperglycemia and dyslipidemia often accompany each other and mutually aggravate the negative effects on blood vessels. Hyperglycemia contributes to lipid metabolism disorders, and dyslipidemia, in turn, can exacerbate insulin resistance and hyperglycemia. Chronic hyperglycemia in diabetes can lead to the development of various complications[13]. Diabetic retinopathy: damage to the blood vessels of the retina, which can lead to poor vision and even blindness. Diabetic nephropathy: kidney damage, which can lead to kidney failure. Diabetic neuropathy: nerve damage that can lead to various symptoms such as numbness, tingling, pain in the extremities[5,6,14]. Cardiovascular disease: myocardial infarction, stroke and other diseases of the heart and blood vessels[1].

Features of the course of hypertension in patients with diabetes. Arterial hypertension (in patients with diabetes mellitus has a number of features that must be taken into account during diagnosis and treatment. In patients with diabetes, hypertension is often combined with other risk factors for cardiovascular diseases, such as obesity, dyslipidemia, insulin resistance and microalbuminuria[4].

A more pronounced increase in blood pressure in patients with hypertensive diabetes mellitus is often characterized by a higher level of blood pressure, especially systolic. Patients with diabetes often experience an increase in blood pressure at night, which may be associated with a disturbance in the circadian rhythm of blood pressure. In patients with diabetes, hypertension may be characterized by greater variability in blood pressure during the day, which can also contribute to the development of complications.

Frequent target organ damage: in patients with diabetes, hypertension occurs more often and more rapidly in target organ damage, such as the heart, kidneys, eyes and brain. Asymptomatic: in many patients with diabetes, hypertension can be asymptomatic or with minimal manifestations, which makes it difficult timely diagnosis.

Diagnosis of hypertension in patients with diabetes includes: Blood pressure measurements should be carried out regularly, both in the doctor's office and independently by the patient at home (self-monitoring of blood pressure). ABPM allows you to assess blood pressure levels throughout the day, including at night, and identify patients with "insufficient reduction" of blood pressure at night.

It is necessary to identify and evaluate all associated risk factors for cardiovascular diseases, such as obesity, dyslipidemia, insulin resistance, smoking, etc. It is necessary to conduct an examination to identify target organ damage, such as ECG, cardiac ultrasound, urine analysis for microalbuminuria, ophthalmoscopy, etc.

Laboratory and instrumental diagnostic methods for arterial hypertension and diabetes mellitus. Diagnosis of arterial hypertension (AH) in patients with diabetes mellitus (DM) includes a set of

laboratory and instrumental research methods aimed at identifying risk factors, assessing the condition of target organs and excluding secondary hypertension. Laboratory research methods.

Lipid profile: Determination of the level of total cholesterol, low-density lipoprotein (LDL), high-density lipoprotein (HDL) and triglycerides. Impaired lipid metabolism (dyslipidemia) often accompanies hypertension and diabetes, increasing the risk of cardiovascular complications. **Biochemical blood test:** Determination of glucose levels in fasting blood and glycated hemoglobin (HbA1c) to assess compensation of carbohydrate metabolism[15].

Determination of creatinine and urea levels to assess kidney function, which often suffer from hypertension and diabetes. Determination of electrolyte levels (potassium, sodium) to identify water-electrolyte imbalances. Determination of liver enzyme activity (ALT, AST) to exclude liver diseases.

General urine test: Determination of the level of protein (albumin) in the urine to identify microalbuminuria, which is an early sign of kidney damage in diabetes and hypertension. **Instrumental research methods.** **Electrocardiogram (ECG):** Registration of the electrical activity of the heart to identify rhythm disturbances, conduction and signs left ventricular hypertrophy. **Echocardiography (ultrasound of the heart):** Ultrasound examination of the heart to assess its structure and function, detect left ventricular hypertrophy, impaired myocardial contractility and other changes. **Ultrasound examination (ultrasound) of blood vessels:** Ultrasound of the carotid arteries to identify atherosclerotic plaques and assess the degree of narrowing of the lumen of blood vessels. Ultrasound of the kidneys to assess their structure and function, identify signs of kidney damage in hypertension and diabetes. Ultrasound of the vessels of the lower extremities to detect atherosclerosis and assess the degree of circulatory disorders. **Ophthalmoscopy:** Examination of the fundus to identify changes in the retinal vessels, which may indicate target organ damage in hypertension and diabetes. **Additional research methods.** Depending on the clinical situation and data obtained during the initial examination, additional research methods may be prescribed. **24-hour blood pressure monitoring (ABPM)** to assess blood pressure fluctuations throughout the day. **Holter ECG monitoring** to detect heart rhythm disturbances. **Stress tests (bicycle ergometry, treadmill test)** to assess exercise tolerance and detect myocardial ischemia. **Coronary angiography** to diagnose coronary heart disease.

Treatment of hypertension in patients with diabetes should be comprehensive. **Lifestyle changes:** it is recommended to follow a diet with limited intake of salt and saturated fats, increase physical activity, quit smoking and alcohol abuse.

Drug therapy: to reduce blood pressure in patients with diabetes, various groups of antihypertensive drugs are used, such as ACE inhibitors, angiotensin II receptor blockers, beta blockers, diuretics, etc[9,10].

The choice of drug depends on the individual characteristics of the patient and the presence of concomitant diseases. **Glycemic control:** it is important to achieve and maintain the target level of glycemia to reduce the risk of developing complications of hypertension. **Lipid control:** it is necessary to monitor the level of lipids in the blood and, if necessary, correct dyslipidemia[10,12].

Strategies for the prevention of arterial hypertension in patients with diabetes mellitus.

Lifestyle correction is the basis for the prevention of hypertension in patients with diabetes. Changing your habits can have a significant impact on your blood pressure levels and overall health. **Diet.** It is recommended to limit salt intake to 5 grams per day[8].

Excess salt contributes to fluid retention in the body and increases blood pressure. The diet should be rich in fruits, vegetables, whole grains, lean meats and fish. You should limit your intake of saturated fats, trans fats and simple carbohydrates. Patients with diabetes need to carefully monitor their carbohydrate intake, especially simple carbohydrates, to avoid sudden fluctuations in blood glucose levels. Alcohol abuse can lead to increased blood pressure. It is recommended to limit alcohol consumption or completely abstain from it.

Physical activity: Moderate physical activity of at least 150 minutes per week is recommended. This could be walking, swimming, cycling or other activities that are enjoyable. The physical exercise program should be selected individually, taking into account the patient's health status and the presence of concomitant diseases. Physical activity: Moderate physical activity of at least 150 minutes per week is recommended. This could be walking, swimming, cycling or other activities that are enjoyable. The physical exercise program should be selected individually, taking into account the patient's health status and the presence of concomitant diseases[10].

Weight loss. Overweight and obesity are risk factors for the development of hypertension and diabetes. Losing even a few kilograms of weight can have a positive effect on blood pressure levels and improve glycemic control. Weight loss should be gradual and safe for health. It is recommended to reduce weight by no more than 0.5-1 kg per week[12].

Quitting smoking. Smoking is one of the main risk factors for the development of cardiovascular diseases, including hypertension. Quitting smoking helps lower blood pressure and improve overall health.

Stress management. Chronic stress can lead to high blood pressure. It is recommended to learn relaxation techniques such as meditation, yoga or deep breathing to reduce stress levels.

Glycemic control. In patients with diabetes, it is important to maintain blood glucose levels within normal limits to reduce the risk of complications, including hypertension.

Regular monitoring by a doctor. Patients with diabetes need to visit their doctor regularly to monitor their blood pressure, blood glucose levels and other health indicators. Timely detection and treatment of hypertension will help prevent the development of serious complications.

Conclusion. Features of the course of hypertension in patients with diabetes require special attention to diagnosis and treatment. Timely detection and correction of hypertension, as well as control of glycemia and other risk factors, will help prevent the development of serious complications and improve the quality of life of patients with diabetes.

Patients with hypertension and diabetes are recommended to undergo a comprehensive examination at least once a year, and more often if indicated. Timely identification and correction of risk factors, as well as adequate treatment of hypertension and diabetes, can significantly reduce the risk of developing cardiovascular complications and improve the quality of life of patients.

Lifestyle correction plays an important role in the prevention of hypertension in patients with diabetes. Changes such as diet, physical activity, smoking cessation, and stress management can have a significant impact on blood pressure levels and improve prognosis in these patients.

Control of hyperglycemia. To prevent and control arterial hypertension in diabetes mellitus, it is important to control blood glucose levels. Recommendations for controlling hyperglycemia include: eating a balanced diet, limiting the intake of simple carbohydrates and saturated fats. Moderate exercise helps reduce blood glucose levels.

The high prevalence of hypertension in patients with diabetes requires an integrated approach to diagnosis and treatment, including lifestyle modification, glycemic control and adequate antihypertensive therapy. Early diagnosis and aggressive treatment of hypertension in diabetics can significantly reduce mortality from cardiovascular diseases.

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