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METABOLIC STRESS AND THE CARDIOVASCULAR SYSTEM: THE HIDDEN DANGERS OF DIABETES

Narzilloyeva Malika Shuhrat kizi

Department of Fundamental Medical Sciences of the Asian International University, Bukhara, Uzbekistan

Annotation : Diabetes mellitus (DM) is a chronic disorder of carbohydrate metabolism and is one of the leading causes of death and disability worldwide. Diabetes induces metabolic stress, which significantly impacts the cardiovascular system. Consequently, a large proportion of diabetic patients die due to cardiovascular complications.

Keywords : Diabetes mellitus, metabolic stress, cardiovascular diseases, atherosclerosis, endothelial dysfunction, oxidative stress, coronary artery disease, heart failure

1. Diabetes and Metabolic Stress

Metabolic stress refers to the body's response to hyperglycemia, dyslipidemia, and oxidative stress. In diabetes, metabolic stress occurs through several key mechanisms:

1. Hyperglycemia: Excess glucose leads to protein and lipoprotein glycation, reducing vascular elasticity.

2. Insulin resistance: Impaired insulin signaling promotes dyslipidemia and endothelial dysfunction.

3. Oxidative stress: Increased free radicals trigger inflammation and accelerate atherosclerosis.

4. Cardiovascular neuropathy: Heart rate variability is reduced, increasing the risk of "silent" myocardial infarction.

The result of metabolic stress is significant structural and functional changes in the cardiovascular system of diabetic patients.

2. Diabetes and Cardiovascular Diseases

The most common cardiovascular diseases in diabetic patients include:

- Coronary artery disease (CAD)
- Myocardial infarction
- Heart failure
- Stroke (ischemic and hemorrhagic)
- Peripheral artery disease

Coronary Artery Disease and Myocardial Infarction

In diabetic patients, myocardial infarctions are often painless or minimally symptomatic. Symptoms may include:

- Shortness of breath
- Tachycardia
- Weakness and fatigue

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• Abdominal or back discomfort

Heart Failure

Diabetic cardiomyopathy, hypertension, and ischemic heart disease collectively contribute to heart failure, often with diastolic dysfunction.

Stroke

Hyperglycemia worsens stroke severity and slows recovery. Diabetic atherosclerosis increases stroke risk 2–4 times.

Peripheral Artery Disease

Diabetic patients have a higher risk of peripheral arterial atherosclerosis, which can lead to gangrene and amputation.

3. Pathophysiological Mechanisms

Glycation and Endothelial Dysfunction

In diabetes, glucose reacts with proteins to form Advanced Glycation End-products (AGEs). This process:

• Stiffens blood vessels

• Reduces endothelial nitric oxide (NO) production

• Increases thrombotic risk

Lipid Imbalance

Insulin resistance leads to:

• Elevated triglycerides

• Increased LDL ("bad cholesterol")

• Decreased HDL ("good cholesterol")

This accelerates atherosclerosis.

Oxidative Stress and Inflammation

Hyperglycemia enhances free radical production, causing:

• Endothelial inflammation

• Formation of atherosclerotic plaques

• Plaque instability

4. Clinical Features and Diagnosis

Key signs to monitor in diabetic patients:

• Altered heart rate and rhythm

• Shortness of breath, fatigue

• Angina pectoris symptoms (may be painless)

• Peripheral vascular changes in limbs

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Diagnostic tools:

- ECG and echocardiography
- Laboratory tests: glucose, HbA1c, lipid profile
- Angiography or coronary CT scan

5. Prevention and Management Strategies

Glycemic Control

- Maintain HbA1c ≤ 7%
- Regular monitoring of blood glucose

Lipid and Blood Pressure Management

- Statins and antihypertensive drugs
- Healthy diet and regular exercise

Lifestyle Modifications

- Smoking cessation
- Weight management
- ≥150 minutes of physical activity per week

Pharmacological Therapy

- Metformin, SGLT2 inhibitors, GLP-1 receptor agonists
- Cardioprotective agents: ACE inhibitors or beta-blockers

Conclusion

The relationship between diabetes and cardiovascular diseases is complex and multifactorial.

Metabolic stress acts as a “hidden danger” to the heart and blood vessels. Effective management requires not only glycemic control but also optimization of lipid profile, blood pressure, and lifestyle factors. Early diagnosis and prevention remain the cornerstone of reducing diabetic cardiovascular complications.

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