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PATHOPHYSIOLOGICAL BASIS OF MICROCIRCULATORY DISORDERS IN DIABETES MELLITUS

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Abstract. This article analyzes the pathophysiological mechanisms of microcirculatory disorders in diabetes mellitus. The roles of chronic hyperglycemia, endothelial dysfunction, oxidative stress, and advanced glycation end products (AGEs) in the development of diabetic microangiopathy are discussed. Structural and functional alterations in capillary blood flow, basement membrane thickening, and pericyte loss are emphasized as key mechanisms leading to diabetic retinopathy, nephropathy, and neuropathy. Modern diagnostic approaches, including HbA1c, microalbuminuria, Doppler ultrasound, OCT, and biomarkers, are also reviewed.

Keywords: diabetes mellitus, microcirculation, endothelial dysfunction, oxidative stress, AGEs, microangiopathy.

Introduction. Diabetes mellitus is a chronic metabolic disorder characterized by persistent hyperglycemia. It affects almost all organ systems, but the microcirculatory network is one of the earliest and most severely affected targets.

Microcirculation refers to blood flow in arterioles, capillaries, and venules, which ensures adequate oxygen and nutrient delivery to tissues. In diabetes, disruption of this system leads to diabetic microangiopathy, which is responsible for most long-term complications of the disease.

Aim of the Study. To analyze the pathophysiological mechanisms of microcirculatory disorders in diabetes mellitus and their clinical significance.

Objectives

1. To evaluate the effects of hyperglycemia on microcirculation.
2. To analyze mechanisms of endothelial dysfunction.
3. To assess the role of advanced glycation end products (AGEs).
4. To investigate oxidative stress in diabetic vascular damage.
5. To study the development of diabetic microangiopathy.
6. To review modern diagnostic approaches.

Main Body. Hyperglycemia and Metabolic Disturbances

Chronic hyperglycemia leads to excessive intracellular glucose accumulation, activating the polyol pathway, protein kinase C (PKC), and increasing oxidative stress.

As a result, microcirculatory changes include:

- reduced capillary blood flow
- increased blood viscosity
- enhanced platelet aggregation

Endothelial Dysfunction. The endothelium plays a central role in vascular tone regulation. In diabetes, nitric oxide (NO) production is significantly reduced. NO↓⇒vasodilation↓NO \downarrow \Rightarrow vasodilation \downarrowNO↓⇒vasodilation↓ This leads to:

- vasoconstriction
- impaired microcirculation
- tissue hypoxia

Advanced Glycation End Products (AGEs)

Excess glucose binds to proteins forming AGEs, which:

- disrupt collagen structure
- increase vascular stiffness
- promote inflammation

Activation of RAGE receptors stimulates NF-κB signaling, enhancing pro-inflammatory cytokine production.

Oxidative Stress

Hyperglycemia increases mitochondrial reactive oxygen species (ROS) production, leading to:

- lipid peroxidation
- DNA damage
- endothelial apoptosis

Oxidative stress is a central mechanism in diabetic vascular injury.

Diabetic Microangiopathy

Structural changes in microvessels include:

- thickening of the basement membrane
- loss of pericytes
- reduced capillary perfusion

These changes contribute to:

- diabetic retinopathy
- diabetic nephropathy
- diabetic neuropathy

Modern Diagnostic Methods. HbA1c. Represents long-term glycemic control.

Microalbuminuria. Early marker of diabetic nephropathy.

Doppler Ultrasound. Assesses microvascular blood flow.

Optical Coherence Tomography (OCT). Detects retinal microvascular changes.

Biomarkers. VEGF, endothelin-1, CRP, IL-6.

Results. Clinical analysis shows that worsening hyperglycemia is directly associated with progressive microcirculatory impairment. Patients with elevated HbA1c demonstrate:

- accelerated microangiopathy
- reduced capillary perfusion
- increased oxidative stress

Discussion. Microcirculatory dysfunction in diabetes is a multifactorial process, with endothelial dysfunction playing a central role. Recent studies highlight AGEs and oxidative stress as potential therapeutic targets. Strict glycemic control and antioxidant therapy may slow the progression of microvascular complications.

Conclusion

1. Diabetes mellitus is a major cause of microcirculatory disorders.
2. Endothelial dysfunction is a key pathogenic mechanism.
3. AGEs and oxidative stress significantly contribute to vascular damage.
4. Microangiopathy underlies major diabetic complications.
5. Early diagnosis is essential for prevention of complications.

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