BG Pulse Journal USA
ISSN:1947-2536 http://www.bgpulseusa.com/index.php/bg

BIOCHEMICAL MECHANISMS OF DIABETES MELLITUS AND ITS IMPACT ON THE ORGANISM

Rustamjonova M. R.
2nd year student, Faculty of General Medicine
Andijan State Medical Institute
Email: sanarella22@gmail.com
Scientific Advisor: **Bokiyev M. M.**
Assistant, Department of Biological Chemistry
Andijan State Medical Institute

Abstract: This article highlights the biochemical mechanisms of diabetes mellitus, namely the metabolic changes that occur as a result of insulin deficiency and insulin resistance. In diabetes mellitus, disturbances in carbohydrate, lipid and protein metabolism are observed and in this condition, the energy supply of the body, tissue functioning and metabolic balance change significantly. Below, the main biochemical indicators of diabetes mellitus and its overall effect on the body are analyzed on a theoretical basis.

Keywords: diabetes mellitus, insulin, insulin resistance, hyperglycemia, glycated hemoglobin, glycogenolysis, gluconeogenesis, lipolysis, ketogenesis, proteolysis.

Introduction: Diabetes mellitus is a chronic metabolic disorder of carbohydrate, lipid, and protein metabolism. Its pathogenesis is based on either a deficiency of insulin secretion or a decreased sensitivity of peripheral tissues to this hormone (insulin resistance) [1]. Insulin is the primary hormone ensuring glucose homeostasis and utilization in the liver, skeletal muscles, and adipose tissue; therefore, when its signaling pathways are blocked, systemic hyperglycemia develops [2]. This pathological condition not only elevates blood glucose levels but also alters intracellular metabolic cascades, fundamentally changing compensatory-adaptive and energy metabolism processes [3]. Consequently, investigating diabetes mellitus at the level of molecular and biochemical mechanisms is of fundamental importance for a deeper understanding of the pathogenesis of disease complications and for the development of pathogenetically based targeted therapies [4].

Literature Review : The literature review indicates that insulin resistance occupies a central role in the pathogenesis of diabetes mellitus, particularly type 2 diabetes. Insulin resistance is a decrease in the biological response of peripheral target tissues to insulin stimulation, manifesting mainly in the liver, skeletal muscle, and adipose tissue [5]. In this pathological condition, post-receptor signal transduction mechanisms are disrupted; consequently, the translocation of specialized glucose transporter proteins, especially GLUT-4, to the cell membrane is impaired, and glucose transport into the cell becomes limited. As a result, glucose utilization in tissues decreases, its concentration in the blood rises, and systemic hyperglycemia develops.

[1] https://www.ncbi.nlm.nih.gov/books/NBK507839
[2] https://emedicine.medscape.com/article/122501-overview
[3] https://www.sciencedirect.com/topics/biochemistry-genetics-and-molecular-biology/ketogenesis
[4] https://www.ncbi.nlm.nih.gov/books/NBK304271
[5] https://share.google/dwBUr6Xl8Rj7QXELw

Because hepatic metabolism is highly sensitive to insulin signaling, insulin resistance eliminates the hormonal inhibition of gluconeogenesis and glycogenolysis at the organ level. Under normal physiological conditions, insulin suppresses gluconeogenic enzymes and activates glycogen synthesis; however, in diabetes, due to the disruption of these regulatory mechanisms, the liver pathologically continues endogenous glucose production. Consequently, glucose synthesis from lactate, glycerol, and amino acids is markedly enhanced, which sustains stable hyperglycemia. This process confirms that diabetes mellitus is not merely a disorder of carbohydrate metabolism but a systemic disease that disrupts overall energy homeostasis.

Alterations in lipid metabolism also constitute a fundamental part of the pathogenesis of diabetes mellitus. Under normal conditions, insulin is a potent antilipolytic hormone that inhibits lipolysis; however, in the setting of insulin deficiency or resistance, triglyceride breakdown in adipose tissue increases, and large amounts of free fatty acids (FFA) are mobilized into the systemic circulation. These acids undergo beta-oxidation in hepatocytes, stimulating the production of acetyl-CoA. If the entry of acetyl-CoA into the Krebs cycle is restricted due to oxaloacetate deficiency, it is diverted toward the ketogenesis pathway, increasing the synthesis of ketone bodies such as acetoacetate, beta-hydroxybutyrate, and acetone. Excessive accumulation of ketone bodies deepens metabolic acidosis. At the same time, increased blood lipid fractions lead to atherogenic dyslipidemia and raise the risk of macro- and microvascular complications of diabetes .

The impact on protein metabolism is also quite significant: insulin, as a clearly anabolic hormone, stimulates protein synthesis and limits proteolysis. Because insulin signaling is impaired in diabetes, protein degradation predominates in skeletal muscle and other tissues . The released amino acids are used as substrates for hepatic gluconeogenesis, resulting in loss of muscle mass and the development of a chronic catabolic state. These processes further deepen the overall energy deficit of the organism and reduce the reparative capacity of tissues.

From a laboratory diagnostic perspective, glycated hemoglobin (HbA1c) is the most important integrative biomarker for assessing the course of diabetes mellitus and the degree of compensation. HbA1c is formed by the non-enzymatic binding of glucose to hemoglobin and reflects the average glucose level over the 120-day lifespan of erythrocytes [6]. Because this covalent binding is stable, HbA1c is more reliable and clinically more informative than a single glycemia measurement. However, the literature notes that certain pathological conditions – such as anemias, hemoglobinopathies, or chronic kidney failure – may affect the interpretation of HbA1c levels . Nevertheless, HbA1c remains the gold standard for long-term monitoring and prognosis of diabetes.

Recent scientific reviews have placed particular emphasis on the roles of oxidative stress and chronic systemic inflammation in the pathogenesis of diabetes mellitus. These processes block insulin signal transduction and enhance mitochondrial dysfunction and cell apoptosis. Thus, diabetes mellitus cannot be limited solely to hyperglycemia; it is a multifactorial, systemic metabolic syndrome characterized by interconnected disturbances of carbohydrate, lipid, and protein metabolism, as well as a complex derangement of cellular signaling and oxidative processes.

[6] https://onlinelibrary.wiley.com/doi/full/10.1002/(SICI)1520-7560(199911/12)15:6%3C412::AID-DMRR72%3E3.0.CO;2-8

Discussion: In November 2025, patients with type 2 diabetes mellitus were examined at the Government Medical Hospital in Sundargarh, India. According to the obtained results: fasting blood glucose levels and HbA1c values were significantly above normal in the patients. The mean HbA1c was 8.4% – an important indicator reflecting the average blood glucose level over three months, with values above 6.5% being diagnostic of diabetes. Furthermore, LDL cholesterol was found to be elevated, while HDL cholesterol was decreased. This condition increases the risk of cardiovascular diseases.

Inflammatory markers – CRP and IL-6 – were also above normal levels. Interestingly, the higher these markers were, the higher the blood glucose levels. That is, increased inflammation in the body leads to impaired insulin function.

Oxidative stress, i.e., processes that cause cellular damage, was also found to be increased. MDA – a substance produced when lipid molecules in cells are damaged – was elevated, while the protective (antioxidant) capacity was reduced. This indicates that the body's self-defense ability is weakened.

The hormone adiponectin, conversely, was low. This hormone helps insulin function properly; it was found that the lower the adiponectin level, the higher the blood glucose level.

Correlation of Biochemical Markers with HbA1c

Marker	r	p-value
Fasting Plasma Glucose	0.63	<0.001
Total Cholesterol	0.45	<0.001
LDL-C	0.38	<0.001
HDL-C	-0.25	<0.001
Adiponectin	-0.42	<0.001
CRP	0.49	<0.001
MDA	0.46	<0.001
TAC	-0.34	<0.001

Statistical analysis identified the three most important predictors: fasting glucose level, CRP (C-reactive protein), and adiponectin. These three parameters were proven to be the best predictors of HbA1c. [7]

Conclusion: Diabetes mellitus is a chronic metabolic disease that develops as a result of impaired insulin secretion or insulin resistance, simultaneously disrupting carbohydrate, lipid, and protein metabolism.

According to the results of the conducted study, hyperglycemia – the main biochemical marker of the disease – is not limited merely to an elevation of blood glucose levels; rather, it is accompanied by metabolic changes such as enhanced gluconeogenesis and activation of lipolysis and proteolysis. Therefore, diabetes mellitus cannot be assessed solely through blood glucose levels – a comprehensive assessment of inflammatory, oxidative stress, and hormonal parameters is

[7] https://healthcare-bulletin.co.uk/article/exploring-biochemical-markers-in-the-diagnosis-and-management-of-type-2-diabetes-mellitus-4840/?hl=ru-RU

necessary to obtain a complete clinical picture of the disease. This is of great importance for early detection, effective monitoring, and prevention of complications.

References

1. Freeman AM, Acevedo LA, Pennings N. Insulin Resistance. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing; 2026. Available from: https://www.ncbi.nlm.nih.gov/books/NBK507839/

2. Goyal R, Jialal I. Diabetes Mellitus Type 2. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing; 2026. Available from: https://emedicine.medscape.com/article/122501-overview

3. Sapra A, Bhandari P. Diabetes Mellitus. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing; 2026. Available from: https://www.ncbi.nlm.nih.gov/books/NBK304271/

4. Ketogenesis [Internet]. ScienceDirect Topics. Elsevier; 2024. Available from: https://www.sciencedirect.com/topics/biochemistry-genetics-and-molecular-biology/ketogenesis

5. Sobirova R.A., Abrorov O.A., Inoyatova F.X., Aripov A.N. Biological Chemistry Part 1. Tashkent: "Yangi asr avlodi"; 2006. 472 p. [Transliterated from Uzbek]

6. Turner RC, Cull CA, Frighi V, Holman RR. Glycemic control with diet, sulfonylurea, metformin, or insulin in patients with type 2 diabetes mellitus. Diabet Metab Res Rev. 1999;15(6):412-417.

7. Mallick M, Dalai J, Sahoo R, Senapati R. Exploring Biochemical Markers in the Diagnosis and Management of Type 2 Diabetes Mellitus. European Journal of Cardiovascular Medicine. 2025;15(12):1354-1358. DOI: 10.61336/ejcm/25-12-225

8. Yusupovna MI, Numonovna MD, Abdujalilovich MZ, A'zamjon o'g'li MT, Erkinjonovna FG, Muzaffarjon o'g'li BM. The Role of the P2X7 Receptor in Cancer Development and Progression. J Neonatal Surg [Internet]. 2025Jun.2 [cited 2025Oct.17];14(27S):1154-6. Available from: https://www.jneonatalsurg.com/index.php/jns/article/view/6921

9. Bokiyev M. M. et al. "AS-MIR" O'ZIQ-OVQAT QOSHILMASINING FENOLLI BIRIKMALARI //Journal of Chemistry of Goods and Traditional Medicine. – 2025. – T. 4. – №. 6. – C. 43-55.

10. Askarov I. R. et al. YERQALAMPIRNING ANTIOKSIDANTLIK XUSUSIYATI //Journal of Chemistry of Goods and Traditional Medicine. – 2022. – T. 1. – №. 3. – C. 217-229.

11. Bokiyev M., Asqarov I. THE IMPORTANCE OF SOME SYNTHETIC DRUGS AND HORSERADISH IN THE TREATMENT OF ATHEROSCLEROSIS //Scientific journal of the Fergana State University. – 2023. – №. 1. – C. 234-234.