INTERRELATIONSHIP BETWEEN ANEMIA, DIABETES MELLITUS, AND RENAL DYSFUNCTION: MECHANISMS, CLINICAL IMPLICATIONS, AND MANAGEMENT

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Abstract. Anemia is a frequent comorbidity in patients with diabetes mellitus (DM), especially when complicated by renal dysfunction. The interplay between hyperglycemia, chronic kidney disease (CKD), and erythropoietin deficiency contributes to the multifactorial pathogenesis of anemia in these patients. This review summarizes the current understanding of molecular mechanisms underlying anemia in diabetic patients, including inflammation-mediated suppression of erythropoiesis, iron metabolism dysregulation, and renal tubular damage. Clinical implications, diagnostic approaches, and therapeutic strategies, such as erythropoiesis-stimulating agents, iron supplementation, and glycemic control, are discussed. Understanding the complex relationship between anemia, diabetes, and renal impairment is critical for optimizing patient outcomes and reducing cardiovascular and morbidity risks.

Keywords: anemia, diabetes mellitus, chronic kidney disease, erythropoiesis, renal dysfunction, iron metabolism.

Introduction. Anemia is a common complication in patients with diabetes mellitus (DM), particularly in those with underlying renal impairment. Studies report that 20–35% of type 2 diabetic patients develop anemia, often before overt kidney failure becomes clinically apparent [1]. The condition significantly worsens patient quality of life, accelerates cardiovascular complications, and increases hospitalization rates. The pathogenesis is multifactorial, involving

erythropoietin deficiency, chronic inflammation, oxidative stress, and nutritional deficiencies [2].

Renal dysfunction in diabetic patients contributes directly to anemia, as damage to renal tubular cells impairs erythropoietin production. Furthermore, chronic hyperglycemia promotes microvascular injury and glomerular sclerosis, exacerbating renal impairment [3,8]. This review aims to synthesize current knowledge on the interplay between anemia, diabetes mellitus, and kidney dysfunction, emphasizing pathophysiological mechanisms, clinical features, and therapeutic interventions.

Pathophysiology

1. Erythropoietin Deficiency and Renal Impairment

Erythropoietin (EPO) is predominantly produced by peritubular fibroblasts in the kidney. In diabetic nephropathy, renal hypoxia, fibrosis, and tubular atrophy reduce EPO synthesis, leading to anemia [4,9,10]. The degree of anemia often correlates with the severity of kidney dysfunction, measured by estimated glomerular filtration rate (eGFR) and proteinuria levels.

2. Inflammation and Oxidative Stress

Chronic hyperglycemia induces systemic low-grade inflammation. Elevated proinflammatory cytokines, including IL-6, TNF-α, and hepcidin, suppress erythropoiesis and impair iron mobilization from storage sites [5]. Oxidative stress damages red blood cell membranes, shortening their lifespan, which further contributes to anemia.

3. Iron Metabolism Dysregulation

Diabetic patients often exhibit functional iron deficiency due to hepcidin-mediated inhibition of intestinal iron absorption and macrophage iron release

[6,11]. Even in the absence of absolute iron deficiency, iron-restricted erythropoiesis reduces hemoglobin synthesis and contributes to anemia severity.

Clinical implications. Anemia in diabetic patients is associated with:

Increased risk of cardiovascular disease and left ventricular hypertrophy;

Reduced exercise tolerance and fatigue;

Accelerated progression of diabetic nephropathy;

Higher rates of hospitalization and mortality [7,10].

Early detection of anemia in diabetics, even before advanced CKD develops, is critical. Hemoglobin measurement, iron studies, EPO levels, and renal function tests are essential components of comprehensive evaluation.

Diagnostic and therapeutic approaches

1. Diagnostic approaches

Complete blood count (CBC) to assess hemoglobin and hematocrit;

Serum ferritin, transferrin saturation, and serum iron to evaluate iron status;

Reticulocyte count to determine bone marrow response;

eGFR and albuminuria to assess renal function;

Inflammatory markers (CRP, IL-6) in selected cases.

2. Management strategies

Erythropoiesis-stimulating agents (ESAs): Used in patients with EPO deficiency and CKD-related anemia.

Iron supplementation: Oral or intravenous iron depending on severity and absorption.

Glycemic control: Optimizing blood glucose reduces oxidative stress and inflammation.

Addressing comorbidities: Blood pressure management, cardiovascular protection, and nutritional support.

The combination of these interventions improves hemoglobin levels, quality of life, and reduces complications associated with anemia in diabetic patients.

Conclusion

Anemia in patients with diabetes mellitus, particularly in the presence of renal dysfunction, represents a multifactorial disorder with significant clinical consequences. Pathogenetic mechanisms include erythropoietin deficiency, chronic inflammation, oxidative stress, and iron metabolism disturbances. Early recognition and targeted treatment, combining glycemic control, iron supplementation, and ESA therapy, are crucial to improving patient outcomes and reducing cardiovascular risk. Further research is required to optimize individualized therapeutic strategies and to better understand the molecular interplay between diabetes, anemia, and kidney dysfunction.

References:

1. Thomas MC, MacIsaac RJ. Anaemia in diabetes: an emerging complication of microvascular disease. Curr Opin Nephrol Hypertens. 2005;14(3):243–247.

2. Gupta A, Dandona P. Diabetes and anemia: pathogenetic mechanisms and clinical implications. Endocr Pract. 2008;14(2):185–192.

3. Astor BC, Muntner P, Levin A, Eustace JA, Coresh J. Association of kidney function with anemia in adults: impact of diabetes. Clin J Am Soc Nephrol. 2006;1(1):28–35.

4. Babitt JL, Lin HY. Mechanisms of anemia in chronic kidney disease. J Am Soc Nephrol. 2012;23(10):1631–1634.

5. Weiss G, Goodnough LT. Anemia of chronic disease. N Engl J Med. 2005;352(10):1011–1023.

6. Ganz T. Iron and inflammation in the anemia of chronic disease. Semin Hematol. 2006;43(4):219–225.

7. Thomas MC, MacIsaac RJ, Tsalamandris C, et al. Anemia in diabetes: effect of erythropoietin therapy on cardiovascular outcomes. Diabetes Care. 2006;29(2):276–281.

8. Делкашева Ш. Д. Особенности развития анемий у больных сахарным диабетом //Экономика и социум. – 2020. – №. 5-1 (72). – С. 537-542.

9. Делкашева Ш. Д. АНЕМИЯ И САХАРНЫЙ ДИАБЕТ: ПРИЧИНЫ ВОЗНИКНОВЕНИЯ И ПРИНЦИПЫ ЛЕЧЕНИЯ //Экономика и социум. – 2022. – №. 2-2 (93). – С. 599-602.

10. Дилкашева Ш. Д. ФАКТОРЫ РИСКА РАЗВИТИЯ ЖЕЛЕЗОДЕФИЦИТНОЙ АНЕМИИ СРЕДИ НАСЕЛЕНИЯ ГОРОДА АНДИЖАНА // Экономика и социум. 2019. №11 (66). URL: https://cyberleninka.ru/article/n/faktory-riska-razvitiya-zhelezodefitsitnoy-anemii-sredi-naseleniya-goroda-andizhana (дата обращения: 06.04.2026).

11. Ахмедова Х. Ю. АНЕМИЯ ХРОНИЧЕСКИХ ЗАБОЛЕВАНИЙ: ПАТОГЕНЕЗ, ДИАГНОСТИКА И ПОДХОДЫ К ТЕРАПИИ // Экономика и социум. 2025. №5-2 (132). URL: https://cyberleninka.ru/article/n/anemiya-hronicheskih-zabolevaniy-patogenez-diagnostika-i-podhody-k-terapii (дата обращения: 06.04.2026).