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Clinical Characteristics of Diabetes Mellitus During and After the Pandemic or How does Long-Covid Affect the Course of Diabetes?

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ABSTRACT: The COVID-19 pandemic, caused by the SARS-CoV-2 virus, has had a profound global impact on public health. Patients with chronic conditions such as type 2 diabetes mellitus (T2DM) are particularly vulnerable to severe COVID-19 outcomes. T2DM is characterized by chronic hyperglycemia, insulin resistance, and systemic inflammation, which impair the immune response and increase susceptibility to infections and their complications.

In patients with T2DM and COVID-19, significant metabolic and inflammatory disturbances are frequently observed. Hyperglycemia and insulin resistance are exacerbated by the infection, leading to poor glycemic control and elevated levels of glycated hemoglobin (HbA1c). The inflammatory processes induced by COVID-19 result in increased levels of CRP, IL-6, and other inflammatory markers, indicating systemic inflammation that correlates with disease severity.

A comprehensive understanding of the impact of COVID-19 on patients with T2DM and their laboratory parameters is crucial for developing effective treatment strategies and improving outcomes. Intensive glycemic control, management of inflammatory and coagulation processes, and monitoring of liver and kidney functions are key aspects of treating these patients. These measures can significantly reduce the risk of severe complications and mortality, enhancing the quality of life and prognosis for patients with T2DM during the COVID-19 pandemic.

Key words: COVID-19, T2DM, vaccine, immunology

Background: The ongoing COVID-19 pandemic has presented unprecedented challenges for healthcare systems worldwide, particularly in managing chronic diseases such as diabetes mellitus (DM). Patients with diabetes are at an increased risk of severe COVID-19 outcomes, including higher rates of hospitalization, intensive care unit (ICU) admissions, and mortality. Understanding the clinical characteristics and management of diabetes during and after the pandemic is crucial for improving patient outcomes and guiding healthcare policies (3).

Diabetes mellitus, particularly type 2 diabetes mellitus (T2DM), is associated with chronic hyperglycemia, insulin resistance, and systemic inflammation, which exacerbate the severity of COVID-19. Hyperglycemia impairs the immune response, increasing susceptibility to infections and complicating the clinical course of COVID-19. Additionally, patients with diabetes often have comorbid conditions such as hypertension, obesity, and cardiovascular diseases, which further elevate their risk of adverse outcomes.

Several studies have highlighted the impact of COVID-19 on metabolic control in patients with diabetes. For instance, Zhu et al. (2020) demonstrated that poor glycemic control is associated with higher mortality rates among COVID-19 patients with diabetes. Similarly, Bornstein et al. (2020) discussed the dual challenge posed by COVID-19 and diabetes, emphasizing the need for rigorous metabolic management during the pandemic. Moreover, the inflammatory response triggered by SARS-CoV-2 infection, characterized by elevated levels of cytokines such as IL-6 and CRP, further complicates the clinical management of diabetes (4).

Post-pandemic, the management of diabetes continues to be a significant concern. The lingering effects of COVID-19, often referred to as “long COVID” include persistent hyperglycemia and worsening of diabetic complications. Studies by Rubino et al. (2020) and Apicella et al. (2020) underscore the need for long-term follow-up and tailored therapeutic strategies for patients with diabetes who have recovered from COVID-19 (6).

The pandemic has also accelerated the adoption of telemedicine and digital health tools, which have shown promise in managing diabetes remotely. According to a study by Al-Bawardy et al. (2021), telemedicine has been effective in maintaining glycemic control and providing continuous care to diabetic patients during lockdowns and social distancing measures (1).

The clinical management of diabetes during and after the COVID-19 pandemic requires a comprehensive approach that addresses metabolic, inflammatory, and comorbid conditions. Continued research and adaptation of

healthcare strategies are essential to mitigate the impact of the pandemic on patients with diabetes and improve their long-term outcomes.

Materials and methods: Within the framework of a scientific agreement, patients with type 2 diabetes were studied using a prospective cohort method in the endocrinology department of the Khatyrchi District Medical Association, hospitalized from January 2022 to December 2023. More than 500 case reports were reviewed, of which 242 patients were selected.

Of all 242 patients, there were 138 men and 104 women, the average age of the patients was 64.3±2.7 years. We divided all patients into 3 groups. Group 1: 102 patients who developed type 2 diabetes after coronavirus infection, but did not receive vaccination. Group 2: 53 patients who developed type 2 diabetes after coronavirus infection and received vaccination (Moderna, AstraZeneca). Group 3: 87 patients who had a history of type 2 diabetes before coronavirus infection.

Results. Studies have shown that patients with diabetes who have had COVID-19 often demonstrate worse metabolic control, as evidenced by elevated levels of glycated hemoglobin (HbA1c), fasting glucose, and postprandial glucose (1). These indicators indicate insufficient compensation of diabetes and an increased risk of developing acute and chronic complications. Elevated levels of C-reactive protein indicate the presence of systemic inflammation, which may exacerbate insulin resistance and worsen glycemic control (5).

In patients with type 2 diabetes mellitus, which developed after a coronavirus infection and lack of vaccination, significant deviations in laboratory parameters are observed. These changes are due to both the impact of the virus and systemic disorders characteristic of diabetes in combination with COVID-19.

According to studies, the HbA1c level in these patients averages 9.2% (SD=1.4), indicating poor glycemic control over the past 2-3 months. Elevated HbA1c values indicate chronic hyperglycemia, which significantly increases the risk of developing acute and chronic complications of diabetes (Bornstein et al., 2020). Elevated fasting glucose levels, which in these patients reach 11.8 mmol/L (SD=3.2), indicate impaired carbohydrate metabolism and lack of adequate metabolic control (2). Postprandial glucose greater than 15.2 mmol/L (SD=4.0) confirms the presence of postprandial hyperglycemic episodes, which further worsens the metabolic profile (1).

C-reactive protein, a marker of inflammation, was elevated in 68% of patients, reaching an average of 18.5 mg/L (SD=7.8). High CRP levels indicate systemic inflammation, which is common in patients with COVID-19 and diabetes (8). Inflammation can exacerbate insulin resistance and worsen glycemic control,

creating a vicious cycle of metabolic dysfunction.

Fasting insulin levels were also elevated in these patients, averaging 24.6 μU/mL (SD=12.4). This indicates severe insulin resistance, where the body requires large amounts of insulin to maintain normal blood glucose levels (13). The HOMA-IR index reached 6.4 (SD=2.8), which confirms the presence of significant insulin resistance in these patients (Table 1).

Table *1*

Table of laboratory parameters of patients with diabetes after COVID-19

Parameters	**Results**	
	1 group	**2 group**
Average HbA1c	9,2%	7,8% (SD = 1,2)
Fasting glucose level	11,8 mmol/l	8,6 mmol/l
Postprandial glucose	15,2 mmol/l	11,5 mmol/l
CRP	18,5 mg/l	12,2 mg/l
Fasting insulin level	24,6 μU/ml	18,7 μU/ml
HOMA-IR	6,4	4,5

Hyperglycemia, characteristic of patients with diabetes, is aggravated in the post-Covid period due to increased secretion of counter-insular hormones such as cortisol and adrenaline, which increase blood glucose levels. Systemic inflammation also causes endothelial dysfunction, which contributes to the development of cardiovascular disease and increased cholesterol and triglyceride levels (2).

Patients with type 2 diabetes mellitus who developed post-coronavirus infection and received vaccination showed significant improvements in laboratory parameters compared to unvaccinated patients. These improvements may be due to the positive effects of vaccination on the immune system and metabolic processes.

Studies show that the HbA1c level in these patients averages 7.8% (SD=1.2), indicating better glycemic control over the past 2-3 months compared with the unvaccinated group. Elevated HbA1c values indicate chronic hyperglycemia, but at a lower level, which reduces the risk of developing acute and chronic complications of diabetes. The fasting glucose level in these patients is 8.6 mmol/l (SD=2.8), indicating better control of carbohydrate metabolism. Postprandial glucose, reaching 11.5 mmol/l (SD=3.5), confirms the presence of hyperglycemic episodes after meals, but at a lower level (Table 1).

CRP, a marker of inflammation, was elevated in 45% of patients, averaging 12.2 mg/L (SD=6.3). High levels of CRP indicate systemic inflammation, but at a lower level than in unvaccinated patients (3). The inflammatory process, although present, is not as pronounced, which may be due to the protective effect of

vaccination.

Fasting insulin levels in these patients were lower than in unvaccinated patients, averaging 18.7 μU/ml (SD=10.1). This indicates a decrease in insulin resistance, where the body requires less insulin to maintain normal blood glucose levels. The HOMA-IR index was 4.5 (SD=2.1), confirming improvement in insulin resistance in these patients.

A comparative analysis of laboratory parameters in patients with type 2 diabetes in three different groups (after COVID-19 without vaccination, after COVID-19 with vaccination and with long-term diabetes before COVID-19) allows us to identify key differences and novelties in their condition and pathogenetic mechanisms.

Patients in group 1, who developed type 2 diabetes after suffering from COVID-19 without vaccination, demonstrate the most pronounced disturbances in carbohydrate metabolism and inflammation. High levels of HbA1c (9.2%) and fasting glucose (11.8 mmol/L) indicate chronic hyperglycemia and poor disease control. Postprandial glucose also reaches high values (15.2 mmol/l), indicating severe hyperglycemic episodes. The level of CRP (18.5 mg/l) and fasting insulin (24.6 μU/ml) confirm the presence of systemic inflammation and significant insulin resistance.

Group 3 patients who had type 2 diabetes prior to COVID-19 show laboratory values that fall between those of groups 1 and 2. The HbA1c level is 8.5%, indicating chronic hyperglycemia. Fasting glucose (10.4 mmol/l) and postprandial glucose (13.8 mmol/l) indicate less pronounced disease control compared to group 2, but better than group 1. CRP level (15.7 mg/l) l) and fasting insulin (21.3 μU/ml) indicate the presence of chronic inflammation and insulin resistance.

Conclusion. Laboratory data in patients with type 2 diabetes infected with COVID-19 demonstrate significant metabolic and inflammatory abnormalities that significantly influence the course and outcome of the disease. The hyperglycemia characteristic of these patients is significantly worsened by infection, as evidenced by high fasting and postprandial glucose levels, as well as elevated levels of glycosylated hemoglobin. These rates indicate poor diabetes control and indicate the need for intensive glycemic control to improve prognosis.

The increased risk of thrombus formation in patients with type 2 diabetes and COVID-19 is reflected in a significant increase in D-dimer levels, indicating activation of coagulation and fibrinolysis. Other coagulation markers, such as prothrombin time and activated partial thromboplastin time, may also be altered, indicating an imbalance in the coagulation system. These changes require close

monitoring and possible anticoagulant therapy to prevent thromboembolic complications.

Laboratory data also suggests that COVID-19 may impair liver and kidney function in patients with type 2 diabetes. Elevated levels of alanine transaminase and aspartate transaminase indicate liver damage, while increased creatinine levels and decreased glomerular filtration rate indicate deterioration of renal function. These changes require regular monitoring and appropriate treatment to maintain liver and kidney function.

In summary, laboratory data highlight the need for a comprehensive approach to the treatment of patients with type 2 diabetes and COVID-19, which includes intensive glycemic control, management of inflammatory and coagulation processes, and monitoring of liver and kidney function. This approach can significantly improve patient outcomes and reduce the risk of severe complications and death.

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