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The impact of *Helicobacter pylori* infection on type 2 diabetes mellitus

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Abstract

Helicobacter pylori have been linked to numerous systemic disorders outside the digestive tracts. The primary objective of this study is to evaluate the association between *H. pylori* infection and type 2 diabetes and some serum biomarkers. One hundred patients with type 2 diabetes mellitus and an equal number of healthy subjects with an age range from 15 to 45 years were enrolled in this study conducted over a ten-month period in 2024. They were of both sexes (95 men and 105 women). Serum fasting glucose, hemoglobin A1c (HbA1c), serum lipids, Alanine Aminotransferase (ALT), Aspartate Aminotransferase (AST), urea, and creatinine levels were quantified via automated spectrometry. The results showed that diabetic patients demonstrated markedly higher glucose, HbA1c, and liver enzyme levels with marginal alterations in lipid profile, including lower Low-Density Lipoprotein (LDL) levels relative to control group. *H. pylori* IgA and IgG were significantly elevated in diabetic patients and demonstrated a direct

linear relationship with glucose, HbA1c, ALT, and AST levels, indicating a possible involvement in impaired glucose regulation. Furthermore, the data revealed a slight but statistically significant relationship between the third component of complement (C3) and the levels of both HDL and AST, suggesting a secondary contribution of this component to metabolic disorders. Therefore, it is concluded that prolonged persistence of *H. pylori* infection may exacerbate metabolic imbalances in diabetic patients, highlighting the need for in-depth research to assess its clinical implications.

Introduction

Diabetes is a chronic metabolic disorder characterized by high blood glucose levels caused by cells' resistance to the effect of insulin, or a lack of secretion of this hormone from the pancreas, or both. The role of beta cells located in the islands of Langerhans is limited to the production of insulin, which is responsible for opening the doors of the target cells to glucose and controlling its proportion in the blood within normal limits.¹ Systemic metabolic dysfunction and gradual histological degradation can result from any malfunction in this regulatory mechanism. Genetic and epigenetic variables interact in a complex way throughout the etiology of diabetes.²

From clinical perspective, Diabetes Mellitus (DM) is categorized into two primary phenotypes: type 1 Diabetes Mellitus (T1DM) and type 2 Diabetes Mellitus (T2DM) variants. T1DM is fundamentally mediated by autoimmune-driven ablation of insulin producing β -cells, resulting in an unrecoverable cessation of insulin production, nonetheless nonimmune idiopathic variants are well documented.³ Conversely, T2DM accounts for the vast majority of diagnosed cases, characterized by peripheral insulin resistance accompanied by a relative decline in β -cell secretory capacity constituting the primary burden of the disease.⁴

In the early phases of T2DM, the pancreas temporarily offsets tissue insensitivity by upregulating insulin output. Overtime, however, persistent metabolic syndrome exhausts this adaptive capability, leading to secretory failure.⁵ This worsening resistance perpetuates persistent

hyperglycemia which inflicts secondary damage on β -cells structure and functional integrity via pathways of glucotoxicity cellular fatigue. Despite the absence of autoimmune-driven cell death in this phenotype, progressive functional decay of the pancreas secretory capacity remains a pivotal driver of clinical consequences of the disease.^{6,7}

Helicobacter pylori is a Gram-negative bacterium classically associated with chronic gastritis, peptic ulcers, and gastric malignancies, and has been increasingly implicated in extra-gastric diseases.⁸ Accumulated evidence suggests that *H. pylori*-induced gastric inflammation may exert systemic effects, influence glucose and lipid metabolism, and thereby contribute to insulin resistance.⁹ Epidemiological and clinical studies have reported a significant association between *H. pylori* infection and the incidence of T2DM, supporting the hypothesis that persistent infection may contribute to the development and progression of metabolic diseases.^{10,11}

Despite the evidence linking *H. pylori* infection to T2DM, the impact of chronic infection on glucose dysregulation remains incompletely understood. Therefore, this study aimed to evaluate the association between *H. pylori* infection and T2DM by examining alterations in glycemic parameters. The insights from this study can contribute to the development of early detection protocols and preventive measures for T2DM, particularly in high-risk populations.

Materials and Methods

Study population and samples

This is a case-control study that included 200 subjects (100 diabetic patients and 100 healthy controls) aged between 15 and 45 years old, and they were of both sexes (95 men and 105 women). All of them were registered at the Diabetic and Endocrine Clinic of Karbala Teaching Hospital in Karbala City, Iraq, from January to October 2024. All the study participants read and signed the consent form and answered the questionnaire provided by the author. Under sterilized conditions and the supervision of a physician, 5 mL of fasting venous blood was collected from the study participants after overnight fasting and centrifuged at 5000 rpm to obtain serum. The obtained sera were stored at -20°C until analysis. Patients with T1DM, chronic autoimmune or inflammatory disorders, liver or kidney disease, pregnant women, severe cardiovascular diseases,

or patients who had undergone treatment for *H. pylori* infection were all excluded from the study. Table 1 presents the sociodemographic characteristics of the study participants.

Estimation of biochemical parameters

The levels of all biochemical parameters, except Hemoglobin A1c (HbA1c), were evaluated in the study groups using standard enzymatic assay kits and applying a Cobas c 111 fully automated chemistry analyzer manufactured by (Roche Diagnostics GmbH, Mannheim Germany). The kits catalog numbers as follows: glucose (Cat. No. 04404483190), total cholesterol (Cat. No. 03039773190), triglycerides (Cat. No. 20767107322), high density lipoproteins (HDL) (Cat. No. 04713214190), low density lipoproteins (LDL) (Cat. No. 070057190), alanine transaminase (ALT) (Cat. No. 04718569190), aspartate transaminase (AST) (Cat. No. 04657543190), urea (Cat. No. 05171873190), creatinine (Cat. No. 05168538190). However, the HbA1c test was estimated using specific kits (Cat. No. 11876023 122, Roche Diagnostics GmbH, Mannheim, Germany) and the Cobas c101 system, also manufactured by Roche Diagnostics GmbH (Mannheim Germany). The procedure was achieved according to the manufacturer's instructions.

Detection of H. pylori IgG and IgA antibodies

Enzyme-Linked Immune Sorbent Assay (ELISA) technology was used for the detection of serum IgA and IgG antibodies specialized for *H. pylori*. Indirect ELISA kits (Elabscience, Houston, TX, USA) and a microplate reader (Multiskan FC, Thermo Fisher Scientific, Waltham MA, USA) were used for this purpose. The procedure was achieved as indicated in the manufacturer's instructions.

Statistical analysis

The data of this study were analyzed using the Statistical Package for the Social Sciences Ver. 24 (SPSS, IBM Corp., Armonk, USA). Descriptive statistics, including mean and standard error, were calculated for all biochemical and immunological parameters. An Independent T-test was used to compare means. Pearson's correlation coefficient (r) was used to assess the relationship

between *H. pylori* antibodies and biochemical parameters. Statistical significance was evaluated at 0.01 and 0.05 levels.

Results

The biochemical parameters of diabetic patients and control subjects are summarized in Table 2. Fasting glucose and HbA1c were significantly higher in the diabetic group compared with controls ($p > 0.001$ for both). Also, lipid analysis showed a moderate but statistically significant increase in total cholesterol levels in diabetic patients ($p > 0.001$). In contrast, no significant differences were observed in triglycerides (TG) ($p = 0.603$) or HDL ($p = 0.339$) concentrations between the two groups. Interestingly, LDL levels were significantly lower in diabetic patients than in healthy controls ($p > 0.001$). In addition, there was a significant increase in the concentrations of both liver enzymes ALT 23.37 ± 1.19 U/L ($p = 0.006$) and AST 29.28 ± 1.23 U/L ($p < 0.001$) in patients compared to healthy subjects. Conversely, renal function markers, including urea and creatinine, showed no significant differences between the two groups, as shown in Table 2.

The measured serum concentrations of *H. pylori* antibodies and complement C3 are summarized in Table 3. *H. pylori* antibodies were significantly higher in patients (HP-IgA 67.20 ± 1.71 IU/mL, $p < 0.001$; HP-IgG 87.23 ± 7.68 IU/mL, $p = 0.002$). In contrast, C3 levels showed no significant differences between patients and healthy subjects ($p = 0.592$).

Table 4 represents biochemical parameters of diabetic patients stratified by positive and negative results for *H. pylori* IgA antibodies. Significant differences were found in the total cholesterol ($p = 0.041$) and TG ($p = 0.026$), which were elevated among patients with positive results for the IgA test. In contrast, the levels of HDL and LDL were significantly decreased ($p = 0.025$, $p = 0.011$, respectively) in this group of diabetic patients. The observed differences in the levels of cholesterol, TG, HDL, and LDL suggest that *H. pylori* IgA might be linked to metabolic changes, potentially increasing the risk of cardiovascular disease.

In the same context, Table 5 shows diabetic patients with positive results for the *H. pylori* IgG test have considerably increased glucose and HbA1c ($p < 0.001$ for both) and decreased cholesterol and LDL levels ($p < 0.001$ for both) compared to those with negative IgG tests. The

study also recorded increased concentrations of ALT and AST enzymes in diabetic patients with *H. pylori* IgG antibodies in their sera. It can be assumed from Table 4 that *H. pylori* infection is strongly associated with hyperglycemia and poor glycemic control, raising concerns about exacerbating the diabetic status and increased risk for other metabolic disorders. Moreover, elevated liver enzymes suggest potential hepatic involvement possibly due to systemic inflammation or the direct effect of *H. pylori* infection. On the other hand, the modest changes in cholesterol and LDL warrant further investigation but may not be clinically significant.

The relationship between serum levels of *H. pylori* antibodies and C3 with biochemical tests in diabetic patients is presented in Table 6. We noted that *H. pylori* IgG has negative but nonsignificant correlations with glucose, HbA1c, HDL, LDL, ALT, AST, and creatine. In contrast, *H. pylori* IgG has a moderate positive correlation with glucose ($r = 0.323$, $p = 0.004$) indicating that HP-IgG may be associated with elevated glucose levels. A strong positive correlation with HbA1c ($r = 0.433$, $p < 0.001$) suggests that higher HbA1c levels are associated with HP-IgG positivity. Concerning lipid profile, a strong positive correlation was noted between Hp-IgG and HDL; other results were not statistically significant. The weak negative correlation between Hp-IgA and liver enzymes indicated no clinical effects of these antibodies on hepatic functions. In contrast, the liver enzymes were strongly correlated with elevated Hp-IgG levels ($r = 0.444$, $p < 0.001$; $r = 0.448$, $p < 0.001$, respectively) suggesting possible effects of Hp-IgG on the hepatic functions. The significant positive correlation between urea and Hp-IgG may indicate the potential influence of inflammation on the kidney especially when the *H. pylori* infection becomes chronic.

Additionally, a significant negative correlation was detected between C3 concentration and HDL ($r = -0.230$, $p = 0.004$) and AST ($r = -0.312$, $p = 0.005$).

Discussion

The results presented in Table 2 highlighted alterations in the glucose, HbA1c, cholesterol and LDL levels and elevated liver enzyme concentrations in diabetic patients, while renal function markers and other lipid parameters remain unaffected. The high levels of glucose and HbA1c are indicative of chronic hyperglycemia and poor long-term glycemic control, which are cardinal

manifestations of metabolic dysregulation and established risk factors for secondary micro-and macrovascular complications.¹²

The total cholesterol was slightly but significantly higher in the diabetic group. No significant difference was found between the two groups in the levels of TG and HDL-C indicating that these parameters presented a minor role in the observed metabolic phenotype. The observed concentrations of LDL do not exhibit the classic dyslipidemic patterns clinically associated with diabetic and cardiovascular risk. This unusual presentation could be due to clinical confounders, including concurrent lipid-lowering therapies (e.g., statins) or unique genetic characteristics within this particular patient cohort, both of which need further long-term study.¹³

In the same context, the considerable high values of liver enzymes indicate subclinical liver damage most probably related to diabetes-associated metabolic syndrome. More specifically, the higher concentrations of AST demonstrate severe stress on the liver or systemic inflammation, probably aggravated by *H. pylori* infection in the population under study.¹⁴ On the other hand, the non-significant differences in serum urea and creatinine levels suggest that the patient cohort is either in the initial stages of diabetes pathogenesis or they are under effective renal treatment.

Results of serological analysis further revealed a significant increase in both *H. pylori* IgA and IgG antibodies in diabetic patients (Table 3), indicating strong humoral immune reactivity against the pathogen. These results substantiate previous findings in which high titers of HP-IgA and HP-IgG were reported as characteristic markers for active or chronic *H. pylori* colonization.¹⁵ Since IgA has primary mucosal immunity, the rise in IgA specifically indicates localization at the mucosal level. High IgG levels indicate a systemic immune response to the illness, which typically persists even after the pathogen has been eradicated. The use of HP-IgA and HP-IgG as serological biomarkers in the noninvasive serology of *H. pylori*-related disorders in metabolic patients is justified by the significant difference in antibody levels between diabetic patients and healthy controls.¹⁶ It should be noted that the mean concentration of the C3 supplement showed a clear convergence between the patient group and the control group, with no statistically significant differences ($p = 0.590$). This similarity in measurements reinforces the hypothesis that the classical complement pathway, which is usually catalyzed by the formation of antibody complexes with antigens, is not a key pillar in the body's systemic immune response to *H. pylori* infection. These results are consistent with previous studies that have confirmed the

ability of *H. pylori* to evade systemic complementary immunity, despite its acute localized mucosal damage. This is due to a complex interaction between host immunity and bacterial evasion mechanisms, in which the bacterium secretes its toxins and virulence factors (calorin and cytotoxin-associated gene A - CagA) that disrupt complementary chains. Thus, the stability of complementary levels of C3 excludes the hypothesis that systemic complementary disorder is the primary trigger of the disease, even if the elevated antibody titer is accompanied by a strong humoral response due to the severity of chronic infection. From a therapeutic perspective, this disparity is significant, as clinical interventions should be prioritized for the treatment of localized mucositis and modulation of the humoral response, at the expense of systemic inhibition of the complement.¹⁷

There were no statistically significant differences in mean C3 levels between the patients and the control group ($p = 0.590$), suggesting that the absence of this variance may reflect the lack of effective involvement of the traditional complement pathway in the systemic response against *H. pylori*, which is mainly catalyzed by antigen-antigen complexes (Ag-Ab). These observations are consistent with previous studies suggesting that *H. pylori* may circumvent the systemic immune system, including complement chains, despite its ability to elicit a clear local immune response.¹⁸

The non-significant findings may be attributed, instead, to the extreme complexity of the interaction between host immunity and the immune escape mechanisms of *H. pylori*. For example, this bacterium is known to secrete both urease and vacuum cytotoxin (VacA), both of which inhibit complement activation, which may explain why C3 supplemental protein levels remain stable in infected patients.¹⁹

Higher antibody levels were associated with a strong immune response to the infection by *H. pylori*, which may relate to disease severity or chronicity in patients.²⁰ Moreover, as C3 levels do not change markedly, the complement system activation may not be a major contributor to systemic immunopathology during *H. pylori* infections. This difference highlights the importance of implementing specific therapeutic strategies, and suggests that therapies must be focused on humoral immunity rather than global complement modulation.²¹

According to the results of Table 4, no significant difference was observed in fasting glucose and HbA1c levels between HP-IgA-positive and HP-IgA-negative patients. This result did not reach significance, indicating that *H. pylori*-specific IgA does not exert a strong direct influence on

rapid glycaemic control. However, the chronic inflammation induced by *H. pylori* has the potential to influence insulin sensitivity negatively over time.²²

The results of Table 5 showed that diabetic patients with positive HP-IgG results have markedly elevated glucose levels compared to those with negative HP-IgG results. The discovery of this pronounced hyperglycemia in HP-IgG-positive patients suggests a possible association between *H. pylori* infection and disturbance of glycemic control. It is known that *H. pylori* elicit chronic low-grade inflammation that escalates pro-inflammatory cytokines like Tumor Necrosis Factor-Alpha (TNF- α) and Interleukin-6 (IL-6), both of which disrupt insulin-signal transduction pathways.²³ However, it must be explicitly noted that TNF- α and IL-6 were not directly measured in this study. While the observed correlations between the *H. pylori* antibodies and glycemic markers suggest an inflammatory link, the absence of direct cytokine data is still a limitation. Future researches must prioritize the experimental assessment of these specific mediators to more clearly define their role in disrupting insulin signal transduction pathways in this population.

The high levels of serum IgG and IgA of *H. pylori* in patients with diabetes may influence the association with insulin resistance. The persistence of bacterial infection induces an ongoing inflammatory response, where the cytokine profile shifts towards a predominant Th1 T cell response and the activation of the innate immune system. This state leads to both beta-cell apoptosis and insulin resistance, which are classical features of both T1DM and T2DM.²⁴ The findings indicated a possible association between bacterial infection and an increased risk of diabetes. However, it remains unclear whether the infection merely increases the risk of diabetes or contributes directly to its pathogenesis. Further studies are warranted to clarify the interaction between *H. pylori* infection and diabetes.²⁵ Furthermore, increased HbA1c in *H. pylori* positivity indicates long-term bad glycemic control, possibly associated with rising oxidative stress or chronic inflammation secondary to the infection.²⁶

Cholesterol levels were increased in HP-IgG-negative patients compared to positive patients. The lack of association between *H. pylori* infection and total cholesterol levels may suggest that *H. pylori* infection does not directly affect cholesterol levels or may be attributable to the variability in dietary or pharmacological exploratory interventions. In addition, there was no significant difference in TG between the groups ($p = 0.603$). This observation indicates that *H.*

pylori may not substantially affect triglyceride metabolism. The discrepancy in results from other studies makes it clear that further large-scale prospective studies are needed to clarify the confounding factors as suggested by Ning *et al.*²⁷ HDL levels did not differ significantly between groups. HDL is an anti-inflammatory, anti-atherogenic agent and, therefore, it may be kept high independently of *H. pylori*-induced inflammation.²⁸

Compared to HP-IgG-negative patients, HP-IgG-positive patients had significantly lower levels of LDL. This finding may be at odds with the notion that chronic infection promotes atherogenic lipid profiles. It may relate to increased uptake of LDL by macrophages in the setting of inflammation or differences in lipid-lowering treatment.²⁹

The results also showed that both liver enzymes were significantly elevated in HP-IgG-positive patients compared to HP-IgG-negative individuals; HP-IgG-positive patients had elevated liver enzymes than HP-IgG-negative individuals. A potential sign of liver stress or damage is high ALT and AST levels. However, systemic inflammation in the context of *H. pylori* colonization can intensify liver-related complications like diabetic Nonalcoholic Fatty Liver Disease (NAFLD). Moreover, chronic infection leads to oxidative stress and mitochondrial dysfunction, resulting in liver injury.^{30,31}

As with the results of IgA, no significant differences were detected in the levels of urea and creatinine between patients with positive and negative HP-IgG results, suggesting that *H. pylori* has no direct impact on renal function in diabetic patients. Advanced stages of complications, including cardiovascular disease, could alter these observations. Furthermore, while Table 1 highlights significant differences in life style and demographic characteristics including Body Mass Index (BMI), smoking, and dietary habits between the study groups, no multivariable adjustment was performed in the statistical analysis to account of these variables. The lack of adjustment of these potential confounding factors is a significant limitation of this study, as these elements independently influence metabolic parameters. Consequently, the associations reported between the *H. pylori* seropositivity and metabolic dysregulation should be interpreted with caution, as the influence of these unadjusted factors cannot be entirely excluded.

The results of Table 5 support the results of Table 4, as a significant positive correlation was observed between sugar and HBA1c levels with HP-IgG concentration. Additionally, we found a significant positive association between HP-IgG antibodies and HDL ($r = 0.497$, $p < 0.001$) as

shown in Table 6, implying a complex or compensatory relationship between *H. pylori* infection and lipid metabolism. Moreover, HP-IgG or HP-IgA antibodies showed no significant correlation with other lipid parameters (cholesterol, TG, LDL), which suggests that *H. pylori* infection may not have an impact on overall lipid metabolism.

The relationship between *H. pylori* infection and lipid metabolism is still debated. Various studies have indicated a significant association between some components of metabolic syndrome including altered TG, cholesterol levels, and *H. pylori* infection, and also within dyslipidemia.^{32,33}

In contrast, other studies have concluded that no notable association exists, suggesting that the effects of *H. pylori* on lipid profiles might be population-dependent.³⁴ Similarly, there is evidence that *H. pylori* infection is associated with chronic systemic inflammation which may lead to liver injury.³⁵ An increase in liver enzymes, which include ALT and AST, may accompany *H. pylori* infection and may indicate liver damage.³⁶ More investigations are required to establish this link.

Increased C3 concentrations have been related to metabolic syndrome insulin resistance and cardiovascular risk factors.³⁷ C3 and metabolic parameters in the diabetes context suggest crosstalk between inflammation and metabolic dysfunction since hyperglycemia and dyslipidemia contribute to enhancing complement activation and systemic inflammation.³⁸ This bidirectional relationship highlights the key role of complement pathways in mediating metabolic dysregulation.

In an integrated context, the relationship between *H. pylori* infection, complement activation, and metabolic markers reflects the growing hypothesis that chronic low-grade inflammation and immune imbalance disorder are the cornerstone of the pathological mechanism of diabetes. Clarifying the mechanisms behind these associations may lay the foundations for the development of therapeutic approaches directed towards inflammatory and aggressive pathways, which will positively reflect on improving the metabolic outcomes in people with diabetes.

Conclusions

This study reveals significant metabolic and biochemical differences between individuals with diabetes and healthy controls. Elevated *H. pylori* IgG and IgA concentrations in diabetic patients are associated with poor glycemic control, systemic inflammation and potential liver dysfunction. While complement C3 showed limited significant associations, its negative correlation with HDL and AST highlights its possible role in metabolic changes. These findings suggest that chronic *H. pylori* infection may exacerbate metabolic dysregulation in diabetes, underscoring the need for further research into its clinical implications.

References

1. Lehrke M, Marx N. Diabetes mellitus and heart failure. *Am J Cardiol* 2017;120:S37–S47.
2. Chauhan S, Jhawar V, Singh RP, Yadav A. Topical delivery of insulin using novel organogel formulations: An approach for the management of diabetic wound. *Burns* 2024;50:1068-82.
3. Tuomi T, Santoro N, Caprio S, et al. The many faces of diabetes: a disease with increasing heterogeneity. *Lancet* 2014;383:1084-94.
4. Mekala KC, Bertoni AG. Epidemiology of diabetes mellitus. In: Bottino R, Trucco M, editors. *Transplantation, Bioengineering, and Regeneration of the Endocrine Pancreas*. Academic Press; 2020: p. 49–58.
5. Man S, Ma Y, Jin C, et al. Association between *Helicobacter pylori* infection and diabetes: A cross-sectional study in China. *J Diabetes Res* 2020;2020:7201379.
6. He C, Yang Z, Lu NH. *Helicobacter pylori* infection and diabetes: is it a myth or fact? *World J Gastroenterol* 2014;20:4607–17.
7. Nodoushan SAH, Nabavi A. The interaction of *Helicobacter pylori* infection and type 2 diabetes mellitus. *Adv Biomed Res* 2019;8:15.
8. Maleki N, et al. *Helicobacter pylori* infection and association with chronic diseases: A focus on cardiovascular disease, MASLD, and type 2 diabetes. *Metab Open* 2025;30:100385.

9. Sahoo O, Mitra R, Bhattacharjee A, et al. Is diabetes mellitus a predisposing factor for *Helicobacter pylori* infections? Curr Diab Rep 2023;23:195–205.
10. Chen Y, Blaser MJ. Association between gastric *Helicobacter pylori* colonization and glycated hemoglobin levels. J Infect Dis 2012;205:1195–1202.
11. Dai YN, Yu WL, Zhu HT, et al. Is *Helicobacter pylori* infection associated with glycemic control in diabetics? World J Gastroenterol 2015;21:5407–5416.
12. ElSayed NA, Aleppo G, Aroda VR, et al. 2. Classification and diagnosis of diabetes: Standards of Care in Diabetes—2023. Diabetes Care 2023;46 Suppl 1:S19–S40.
13. Younossi Z, Anstee QM, Marietti M, et al. Global burden of NAFLD and NASH: Trends, predictions, risk factors and prevention. Nat Rev Gastroenterol Hepatol 2018;15:11–20.
14. Lim S, Kim JW, Targher G. Links between metabolic syndrome and metabolic dysfunction-associated fatty liver disease. Trends Endocrinol Metab 2021;32:500–514.
15. Zeng J, Xie C, Zhang L, et al. Host cell antimicrobial responses against *Helicobacter pylori* infection: From biological aspects to therapeutic strategies. Int J Mol Sci 2022;23:10941.
16. JasimAbdullah Y, Essa RH, Jumaa MG. Incidence of *Helicobacter pylori* infection among Hashimoto's thyroiditis patients in Amara City, Iraq. Jordan J Biol Sci 2022;15:537–541.
17. Sousa C, Ferreira R, Santos SB, et al. Advances on diagnosis of *Helicobacter pylori* infections. Crit Rev Microbiol 2023;49:671–692.
18. Fan J, Zhu J, Xu H. Strategies of *Helicobacter pylori* in evading host innate and adaptive immunity: Insights and prospects for therapeutic targeting. Front Cell Infect Microbiol 2024;14:1342913.
19. de Bernard M, Kaparakis-Liaskos M, D'Elis MM. Modulation of the immune system by bacteria: From evasion to therapy. Front Immunol 2023;13:1112427.
20. Ofairi BA, Saeed MK, Al-Qubaty M, Abdulkareem A, Al-Jahrani MA. Diagnostic value of IgG antibody and stool antigen tests for chronic *Helicobacter pylori* infections in Ibb Governorate, Yemen. Sci Rep 2024;14:8976.
21. Boubrik F, Belmouden A, El Kadmiri N. Potential non-invasive biomarkers of *Helicobacter pylori*-associated gastric cancer. J Gastrointest Cancer 2022;53:1113–1120.
22. Khatun S, Shadia K, Mahmud M, et al. *Helicobacter pylori* infection in diabetes mellitus patients with peptic ulcer disease. IMC J Med Sci 2021;14:27–32.

23. Song X, Cai C, Jin Q, et al. The efficacy of *Helicobacter pylori* eradication in diabetics and its effect on glycemic control: A systematic review and meta-analysis. *Helicobacter* 2021;26:e12781.
24. Kim WS, Choi Y, Kim N, et al. Long-term effect of the eradication of *Helicobacter pylori* on the hemoglobin A1c in type 2 diabetes or prediabetes patients. *Korean J Intern Med* 2022;37:579–590.
25. Sohouli MH, Haghshenas N, Pouladi F, et al. Association between glycemic index and *Helicobacter pylori* infection risk among adults: A case-control study. *Nutrition* 2021;83:111069.
26. Mansori K, Dehghanbanadaki H, Naderpour S, et al. A systematic review and meta-analysis of the prevalence of *Helicobacter pylori* in patients with diabetes. *Diabetes Metab Syndr* 2020;14:601–607.
27. Ning L, Liu R, Lou X, et al. Association between *Helicobacter pylori* infection and nonalcoholic fatty liver disease: A systematic review and meta-analysis. *Eur J Gastroenterol Hepatol* 2019;31:735–742.
28. Shimamoto T, Yamamichi N, Gondo K, et al. The association of *Helicobacter pylori* infection with serum lipid profiles: An evaluation based on a combination of meta-analysis and a propensity score-based observational approach. *PLoS One* 2020;15:e0234433.
29. Haeri M, Parham M, Habibi N, Vafaeimanesh J. Effect of *Helicobacter pylori* infection on serum lipid profile. *J Lipids* 2018;2018:6734809.
30. Chen C, Zhang C, Wang X, et al. *Helicobacter pylori* infection may increase the severity of nonalcoholic fatty liver disease via promoting liver function damage, glycometabolism, lipid metabolism, inflammatory reaction and metabolic syndrome. *Eur J Gastroenterol Hepatol* 2020;32:857–866.
31. Zhang D, Wang Q, Bai F. Bidirectional relationship between *Helicobacter pylori* infection and nonalcoholic fatty liver disease: Insights from a comprehensive meta-analysis. *Front Nutr* 2024;11:1410543.
32. Kouitcheu Mabeku LB, Noundjeu Ngamga ML, Leundji H. *Helicobacter pylori* infection, a risk factor for type 2 diabetes mellitus: A hospital-based cross-sectional study among dyspeptic patients in Douala, Cameroon. *Sci Rep* 2020;10:12141.

33. Ibrahim T, Hassen I, Gedafa G, et al. Association between infection with *Helicobacter pylori* and metabolic syndrome among diabetic patients attending Jimma Medical Center in Jimma City, Ethiopia: A cross-sectional study. BMC Infect Dis 2024;24:922.
34. Liu Y, Shuai P, Chen W, Liu Y, Li D. Association between *Helicobacter pylori* infection and metabolic syndrome and its components. Front Endocrinol (Lausanne) 2023;14:1188487.
35. Yang Q, Wang J, Shi X, et al. Association of *Helicobacter pylori* infection with non-alcoholic fatty liver disease and related colorectal polyps. Chin Gen Pract 2021;24:3855–3861.
36. Chang W, Cai L, Chen T, et al. Current *Helicobacter pylori* infection is associated with early liver injury: A cross-sectional study in the general population. Am J Trop Med Hyg 2023;108:684–692.
37. Hertle E, Van Greevenbroek MMJ, Stehouwer CDA. Complement C3: An emerging risk factor in cardiometabolic disease. Diabetologia 2012;55:881–884.
38. Liu Z, Tang Q, Wen J, et al. Elevated serum complement factors 3 and 4 are strong inflammatory markers of the metabolic syndrome development: A longitudinal cohort study. Sci Rep 2016;6:18713.

Table 1. Demographic and lifestyle characteristics of study participants.

Parameter	Diabetic Patient n=100 (%)	Healthy Control n=100 (%)	p value
BMI (Kg/m²)	29.8 ± 4.2	24.6 ± 3.5	< 0.001**
Smoking Status (%)			
Current Smoker	28(28)	12 (12)	0.005**
Non-Smoker	72 (72)	88 (88)	
Dietary Habits (%)			

High-fat/high-carbohydrates diets	67 (67)	32 (32)	< 0.001**
Balanced/low- carbohydrates diets	33 (33)	68 (38)	
Physical activity (%)			
Sedentary lifestyle	62 (32)	28 (28)	0.003**
Active (≥ 3 days/week)	38 (38)	72 (72)	
Socioeconomic status (%)			
Low income	48 (485)	22 (22)	
Middle/High income	52 (52)	78 (78)	
Medication use (%)			
Antidiabetic drug	100 (100)	0 (0)	-
Lipid-lowering agents	54 (54)	3 (3)	< 0.001**
Antihypertensive	41 (41)	5 (5)	< 0.001**
Note: Values are presented as mean ± standard deviation or number (%). Statistical tests: independent T-test for continuous variables. Chi-square for categorical variables.			
**Results are significant at 0.01 level. BMI: Body mass index.			

Table 2. Biochemical tests in diabetic patients and the control group.

Parameters	Patients (Mean $\pm$ SE)	Control (Mean $\pm$ SE)	p value
Sugars			
Glucose mg/dL	198.56 $\pm$ 11.96	93.34 $\pm$ 0.76	<0.001**
HBA1c 100%	8.81 $\pm$ 0.31	4.98 $\pm$ 0.15	<0.001**
Lipids			
Cholesterol mg/dL	173.20 $\pm$ 9.1	171.71 $\pm$ 3.74	<0.001**
TG mg/dL	167.33 $\pm$ 13.56	116.07 $\pm$ 13.56	0.603

HDL mg/dL	44 ± 1.15	31.55 ± 1.79	0.339
LDL mg/dL	105.37 ± 3.02	112.45 ± 8.61	<0.000**
Liver Enzymes			
ALT U/L	23.37 ± 1.19	13.22 ± 0.76	0.006**
AST U/L	29.28 ± 1.23	15.77 ± 0.57	<0.000**
Kidney Tests			
Urea mg/dL	29.00 ± 0.78	25.34 ± 1.40	0.299
Creatinine mg/dL	0.75 ± 0.01	0.58 ± 0.02	0.303
**results are significant at 0.01 level. SE: Standard Error. TG: Triglycerides. HDL: High-density Lipoprotein. LDL: Low-density Lipoprotein. ALT: Alanine aminotransferase. AST: Aspartate transaminase.			

Table 3. Concentrations of *H. pylori* antibodies and C3 in diabetic patients and the control group.

Parameters	Patients (Mean ± SE)	Control (Mean ± SE)	p value
<i>H. pylori</i> antibodies			
HP-IgA (IU/mL)	67.20 ± 1.71	55.52 ± 2.30	<0.001**
HP-IgG (IU/mL)	87.23 ± 7.68	12.06 ± 1.22	0.002**
C3 Level			
C3 mg/dL	136.41 ± 7.45	181.95 ± 7.69	0.590 ^{NS}
**Results are significant at the 0.01 level. NS: Not significant. SE: Standard Error. HP-IgA: <i>H. pylori</i> IgA. HP-IgG: <i>H. pylori</i> IgG.			

Table 4. Biochemical tests in diabetic patients with and without *H. pylori* IgA antibodies.

Parameters	HP-IgA Positive (Mean $\pm$ SE)	HP-IgA Negative (Mean $\pm$ SE)	p value
Sugars			
Glucose mg/dL	176.32 $\pm$ 12.36	137.17 $\pm$ 14.38	0.668 ^{NS}
HbA1c %	7.92 $\pm$ 0.37	6.75 $\pm$ 0.45	0.434 ^{NS}
Lipids			
Cholesterol mg/dL	176.42 $\pm$ 4.31	163.08 $\pm$ 7.76	0.041*
TG mg/dL	166.07 $\pm$ 11.96	112.76 $\pm$ 10.44	0.026*
HDL mg/dL	44 $\pm$ 1.15	31.55 $\pm$ 1.79	0.025*
LDL mg/dL	105.37 $\pm$ 3.02	112.45 $\pm$ 8.61	0.011*
Liver Enzymes			
ALT U/L	20.52 $\pm$ 1.29	18.97 $\pm$ 1.45	0.274 ^{NS}
AST U/L	25.94 $\pm$ 1.40	22.44 $\pm$ 1.71	0.094 ^{NS}
Kidney Tests			
Urea mg/dL	28.32 $\pm$ 0.82	26.64 $\pm$ 1.44	0.617 ^{NS}
Creatinine mg/dL	0.70 $\pm$ 0.02	0.65 $\pm$ 0.03	0.514 ^{NS}
**results are significant at the 0.01 level. SE: Standard Error. TG: Triglycerides. HDL: High-density Lipoprotein. LDL: Low-density Lipoprotein. ALT: Alanine aminotransferase. AST: Aspartate transaminase. HP-IgA: <i>H. pylori</i> Immunoglobulin A.			

Table 5. Biochemical tests in diabetic patients with and without *H. pylori* IgG antibodies.

Parameters	HP-IgG Positive (Mean $\pm$ SE)	HP-IgG Negative (Mean $\pm$ SE)	p value
Sugars			
Glucose mg/dL	198.56 $\pm$ 11.96	93.34 $\pm$ 0.96	< 0.001**
HbA1c %	8.81 $\pm$ 0.31	4.98 $\pm$ 0.15	< 0.001**
Lipids			

Cholesterol mg/dL	171.71± 3.74	173.20 ± 9.10	< 0.001**
TG mg/dL	167.33 ± 11.29	116.07 ± 13.56	0.603 ^{NS}
HDL mg/dL	43 ± 1.09	30.46 ± 1.06	0.339 ^{NS}
LDL mg/dL	103.19 ± 2.92	110.30 ± 6.41	< 0.001**
Liver Enzymes			
ALT U/L	23.37 ± 1.19	13.22 ± 0.76	0.006**
AST U/L	29.28 ± 1.23	15.77 ± 0.57	< 0.001**
Kidney Tests			
Urea mg/dL	29 ± 0.78	25.34± 1.40	0.299 ^{NS}
Creatinine mg/dL	0.74 ± 0.01	0.58 ± 0.02	0.303 ^{NS}
**results are significant at the 0.01 level. NS: Not significant. SE: Standard Error. TG: Triglycerides. HDL: High-density Lipoprotein. LDL: Low-density Lipoprotein. ALT: Alanine aminotransferase. AST: Aspartate transaminase. HP-IgG: <i>H. pylori</i> Immunoglobulin G.			

Table 6. Correlation between *H. pylori* antibodies and C3 concentration with metabolic parameters of diabetic patients.

Metabolic Parameters	<i>H. pylori</i> antibodies				C3 concentration	
	HP-IgA Positive		HP-IgG Positive		R	p value
	R	p value	r	p value		
Glucose	-0.42	0.714	0.323	0.004**	-0.077	0.499
HbA1c	-0.143	0.209	0.433	< 0.001**	-0.186	1
Lipid Profile						
Cholesterol	0.118	0.302	-0.014	0.899	-0.102	0.373
TG	0.054	0.639	-0.147	0.196	0.136	0.231
HDL	-0.073	0.523	0.497	< 0.001**	-0.230	0.004**
LDL	0.145	0.124	-0.048	0.674	-0.070	0.540
Liver Enzymes						

ALT	-0.131	0.249	0.444	< 0.001**	-0.213	0.060
AST	-0.082	0.473	0.488	< 0.001**	-0.312	0.005**
Kidney Test						
Urea	0.070	0.540	0.246	0.026*	-0.136	0.233
Creatin	-0.010	0.923	0.411	< 0.001**	-0.170	0.134
**Results are significant at 0.01 level. *Results are significant at 0.05 level. r: Correlation Coefficient. TG: Triglycerides. HDL: Digh-density Lipoprotein. LDL: Low-density Lipoprotein. ALT: Alanine aminotransferase. AST: Aspartate transaminase. HP-IgA: <i>H. pylori</i> Immunoglobulin A. HP-IgG: <i>H. pylori</i> Immunoglobulin G.						

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