Academic Science Journal

The Importance of Biochemical Markers in Diagnosing, Managing and Predicting Diabetes Mellitus

Ali S Mahmoud Al-saadi*

Department of chemistry, College of Science, University of Diyala, Baqubah, Iraq

* Ali_alsaady70@yahoo.com

Received: 9 March 202 **Accepted: 7 May 2025**

Published: July 2025

DOI: https://dx.doi.org/10.24237/ASJ.03.03.962A

Abstract

Diabetes mellitus (DM) is a complex and widespread metabolic disorder marked by persistent hyperglycemia resulting from defects in insulin secretion, insulin action, or both. Despite advances in therapy, conventional treatment approaches often fail to address the individual variability among patients, leading to suboptimal glycaemic control and increased risk of complications. Recent advances in biomedical science have highlighted the importance of biochemical markers in the early detection, classification, and management of diabetes. These markers not only aid in disease monitoring but also support the development of personalized treatment strategies aimed at improving patient outcomes. As the prevalence of DM continues to rise globally, especially in developing regions, exploring the role of precision medicine through biochemical and biometric profiling has become increasingly important in optimizing care and reducing long-term complications. Samples were collected from different hospitals in Diyala Governorate (Baquba Teaching Hospital- Diyala, Al-Zahraa Hospital- Shahraban and Al-Khalis Hospital- Khalis).

The study included 90 patients with diabetes (T1DM, T2DM, and gestational diabetes). Their ages ranged from 25 to 70 years. The male-female ratio was 38/52. The ratio of t T2DM diabetes was 47/90, T1DM diabetes 17/90, and gestational diabetes 26/90. The duration of samples

collection reached 10 months. This study analyses selected diabetes cases and explores the role of biochemical markers in designing individualized therapies, which are: HbA1c, LDL, and triglyceride in addition to the biometric variables: body weight and BMI.

Key findings demonstrate improved glycaemic control, reduced cardiovascular risks.

The results have shown that personalized biochemical markers-based therapies significantly improve blood sugar control, reduce systemic inflammation, and reduce cardiovascular risk in patients with diabetes. By tailoring treatment plans based on individual profiles, physicians are able to achieve better overall outcomes, highlighting the potential of precision medicine in diabetes management.

The present study emphasized the critical role of personalized medicine in follow – up of diabetes patients, improving treatment efficacy, reducing side effects, and improving patient outcomes.

Keywords: Gestational diabetes, Insulin resistance, biomarker Analysis, HbA1c.

Introduction

Diabetes is a global health challenge that chronically affects millions of people of all ages, ethnicities, and socioeconomic backgrounds [1] [2]. The prevalence of diabetes is hyperglycaemia [3], caused by defective insulin secretion, defective insulin action, or a combination of the two, and continues to rise with aging, sedentary lifestyles, and dietary changes [4]. DiabetesT2DM accounts for 90% of all cases, and the burden of this increase is significant and has a profound impact on health care systems worldwide, requiring new approaches to improve services and outcomes [5]. DM each subtype exhibits distinct pathophysiological mechanisms clinical presentations and developmental patterns for example [6] [3], T1DM is primarily autoimmune dysfunction and destruction of intestinal beta cells, whereas T2DM is often caused by genetic associated with insulin resistance andβ-cell dysfunction due to environmental factors, presenting with GDM during pregnancy and associated with fatal maternal health risks [7]. These differences in individual patient characteristics emphasize the need for personalized treatment using biomarkers as an important tool in personalized medicine research [8] [9]. These biomarkers provide insight into the pathophysiology underlying DM, enabling the identification of patient subgroups and the

development of appropriate treatment strategies [10] [11]. The integration of biomarker assessment into clinical practice has revolutionized the management of DM [12] [13]. Traditional single-factor approaches often fail to account for individual differences in disease progression, comorbidities, and response to treatment, and physicians'biomarker-indexedstrategiesforspecificpatientsoftenyieldsuboptimalresults [14] [15]. As opposed to -you can develop treatments based on profiles for example anti-inflammatory therapies targeting elevated CRP [16], GLP-1 receptor agonists and SGLT2 inhibitors are expected to reduce systemic inflammation and improve glycaemic control by identifying patients with specific metabolic and cardiovascular risks [17] [18].

Biomarkers such as HbA1c, a key indicator of long-term glycaemic control [19]; LDL, a marker of cardiovascular risk [20]; and triglycerides, linked to metabolic health, are vital for tailoring therapies [21]. Additionally, biometric measures like body weight and BMI provide insights into obesity-related risks, further aiding in individualized diabetes management strategies [22].

Material and Methods

Patient's selection:

Selection Patients with confirmed diabetes were selected according to standardized diagnostic criteria. Data on biomarkers, treatment regimens and clinical outcomes were collected. Patients with different age, gender, and diabetes subtypes were selected.

Determination of the biochemical parameters:

This study focused on key biochemical markers relevant to glycaemic control, pancreatic function, lipid metabolism, autoimmunity, and inflammation. HbA1c was measured to evaluate long-term blood glucose regulation [19].

, while C-peptide levels provided insight into residual pancreatic beta cell activity [20], particularly distinguishing between T1DM and T2DM. Triglycerides and LDL cholesterol were assessed as indicators of dyslipidaemia and cardiovascular risk [21] [22]. Anti-GAD antibodies served as autoimmune markers to confirm T1DM diagnosis [23] [24]. Additionally, emerging inflammatory biomarkers such as visfatin and serum amyloid A (SAA) were Modified included to explore their potential role in diabetes-related metabolic and inflammatory pathways [25]

[26]. Data were obtained from patient medical records, encompassing routine lab tests and specialized immunoassays.

Types of treatment and their Biochemical role:

Treatment Role: The treatment role was divided by the type of treatment prescribed, according to the patient's medical records, respectively, with some specific interventions related to (lifestyle modification through diet quality control, weight loss, exercise), and some patterns leading to weight loss due to the type of medication originally prescribed. These were some of the medications documented in the patients' records. Which are:

Metformin: to improve insulin sensitivity [27] [28]. GLP-1 and SGLT2 receptor blockers: to help with weight loss and control blood sugar levels [29] [30].

Insulin therapy: for T2DM diabetes and some cases of gestational diabetes; DPP-4 inhibitors: for patients with moderate hyperglycaemia [31] [32].

Statins: to reduce cardiovascular risk in patients with elevated LDL levels [33].

Anti-inflammatory agents: for patients with elevated CRP or IL-6 levels [34] [35].

Lifestyle modifications:

Dietary interventions: focused on reducing calories and improving macronutrient distribution.

Exercise programs: aimed at improving insulin sensitivity and weight control.

Outcome Assessment

Clinical outcomes were measured over a follow-up period of 8 to 10 months.

The main outcome measures were as follows: Glycaemic control: a decrease in HbA1c of at least 1.0% was considered significant.

Weight loss: documented in patients receiving GLP-1 receptor agonists and SGLT2 inhibitors.

Reduction in cardiovascular risk: assessed by improvement in triglyceride and LDL cholesterol levels.

Data Analysis:

Quantitative analysis: Outcome data were analysed for patients who showed significant improvement in HbA1c and other therapeutic parameters. Predictors were identified from biomarkers and a wide range of therapeutic interventions.

Qualitative analysis: Case-based observations highlighted individual responses, especially in complex cases, such as very high-risk and poorly controlled cases of T2DM diabetes. This retrospective analysis included 90 diabetic patients, using biomarkers such as HbA1c, C-peptide, triglycerides, and anti-GAD antibodies, as well as novel markers such as visfatin and serum amyloid A. Therapeutics were categorized as biomarkers, health care contributors (e.g., metformin, GLP-1 therapy, therapeutic agents), and lifestyle modifications Outcomes such as HbA1c, weight loss, and patient responsibility were recorded over 10 months.

Statistical Analysis:

Statistical Methods Used:

1. Paired Sample t-Test:

Purpose: To compare the mean values before and after treatment within the same group of patients.

Application:

Applied to HbA1c levels, weight, BMI, LDL cholesterol, and triglyceride levels (as shown in Tables 1, 2, and 3).

This test assessed whether the mean difference before and after treatment was statistically significant.

Significance threshold: A p-value < 0.05 was considered statistically significant.

Rationale: The paired t-test is ideal when evaluating the impact of an intervention on the same subjects over time.

2. Descriptive Statistics:

Mean ± Standard Deviation (SD):

Reported to describe central tendency and variability for each parameter.

Useful for interpreting the average effectiveness of each treatment.

3. Subgroup Analysis:

Conducted to evaluate differences across diabetes subtypes (T1DM, T2DM, and GDM).

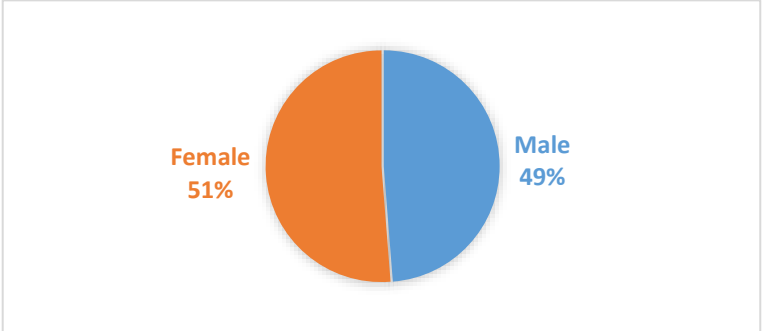
Allowed insights into treatment effectiveness across various clinical profiles.

4. Clinical Relevance vs. Statistical Significance:

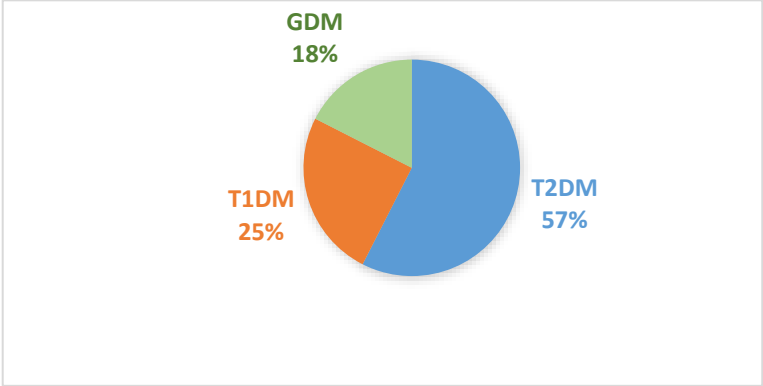
Academic Science Journal

While statistical significance ($p < 0.05$) confirms that changes are unlikely due to chance, Clinical relevance was also considered by identifying thresholds of improvement.

Results and Discussion



Figures 1: Distribution of the cases enrolled in the present study by gender.



Figures 2: Distribution of the cases enrolled in the present study By Type of Diabetes.

Table 1: HbA1c level before and after Treatment

Treatment type	HbA1c (%) before treatment	HbA1c (%) after treatment	p-value	**Notes**
Metformin	9.2 ± 1.1	7.7 ± 0.9	<0.05	80% of GDM patients reached HbA1c < 6.0%
GLP-1 Receptor Agonists	9.0 ± 1.3	7.0 ± 1.1	<0.05	Mean HbA1c reduction: **1.5%**
SGLT2 Inhibitors	9.1 ± 1.2	7.3 ± 1.0	<0.05	Mean HbA1c reduction: **1.5%**
Insulin Therapy	9.4 ±1.4	7.8 ± 1.3	<0.05	Used in T1DM and GDM; 80% of GDM cases reached HbA1c < 6.0%
Lifestyle Modifications	8.8 ± 1.0	7.4 ± 1.1	<0.05	Effective in early-stage T2DM
Combination Therapy	9.3 ± 1.3	7.2 ± 1.0	<0.05	Often used in T2DM with obesity/metabolic syndrome

Controlling blood sugar levels

Reducing HbA1c:

Overall improvement: 85% of patients achieved a clinically significant reduction in HbA1c of at least 1.0%.

Subtype trends:

Patients taking GLP-1 receptor antagonists or SGLT2 inhibitors improved the most, with a mean reduction in HbA1c of 1.5%. Gestational diabetes mellitus (GDM) patients treated with metformin or insulin had normal HbA1clevelsbelow 6.0% in 80% of cases (Table-1).

Table 2: Weight and BMI before and after treatment

Treatment type	Weight Before (kg)	Weight After (kg)	p-value	BMI Before (kg/m²)	BMI After (kg/m²)	p-value
Metformin	85 ± 10	82 ± 9	<0.05	32 ± 3.0	30.9± 2.8	<0.05
GLP-1 Receptor Agonists	88 ± 12	82 ± 11	<0.05	33 ± 32	31 ±3.1	<0.05
SGLT2 Inhibitors	87 ± 11	83 ± 10	<0.05	32.5± 2.8	31± 2.7	<0.05
Lifestyle Modifications	84 ± 8	81 ± 7	<0.05	31 ± 2.7	30± 2.6	<0.05

Weight Loss

Patients on GLP-1 receptor agonists or SGLT2 inhibitors experienced the most significant weight loss, with an average of 5-7% reduction in base line weight(table-2) [30] [29].

Weight loss was particularly pronounced in T2DM patients with obesity, contributing to improved insulin sensitivity and cardiovascular risk profiles, table-2.

Table 3: Lipid profile levels (LDL and triglycerides before and after treatment).

Treatment type	LDL Before (mg/dL)	LDL After (mg/dL)	p-value	Triglycerides Before (mg/dL)	Triglycerides After (mg/dL)	p-value
Metformin	140 ± 20	120 ± 18	<0.05	180 v 25	155 ± 20	<0.05
GLP-1 Receptor Agonists	145 ± 22	115 ±19	<0.05	185 ± 30	150 ± 22	<0.05
SGLT2 Inhibitors	142 ± 18	118 ± 17	<0.05	182± 28	160 ± 25	<0.05
Insulin Therapy	138 ± 21	125 ± 20	<0.05	175 ± 22	165 ±20	<0.05

P-ISSN: 2958-4612
E-ISSN: 2959-5568

Reducing Cardiovascular Risk

Triglycerides and LDL cholesterol:Two studies have shown that 70% of patients with high triglyceride levels (>175 mg/dL) achieved at least a 20% reduction when using GLP-1 receptor agonists or statin therapy, Table-3 [21] [36] . LDL cholesterol levels also improved significantly in patients taking statins, with a median reduction of 25 mg/dL as shown in table 3.

This study demonstrates the effectiveness of biomarker-based precision medicine in improving outcomes for patients with different types of diabetes by aligning treatment strategies with individual biochemical profiles [33] [37]. The reduction in systemic inflammation was strongly associated with improved glycaemic control, suggesting a clear link between inflammatory processes and insulin resistance. Markers such as C-reactive protein (CRP) and interleukin-6 (IL-6) decreased significantly in patients receiving anti-inflammatory therapies, such as GLP-1 receptor agonists and SGLT2 inhibitors, supporting their dual role in managing both glucose metabolism and cardiovascular risk.

In T1DM patients, the presence of anti-GAD antibodies guided the application of immunotherapy in conjunction with insulin, which enhanced glucose stability and reduced insulin dependency [23] [24] [38]. Similarly, C-peptide levels were used to evaluate residual beta-cell function, aiding in the distinction between T1DM and T2DM and helping to refine treatment approaches. In T2DM, particularly among obese patients with elevated triglycerides and LDL cholesterol, the use of GLP-1 receptor agonists, SGLT2 inhibitors, and statins resulted in significant lipid profile improvements, contributing to reduced cardiovascular risk. These patients also experienced weight loss and better glycaemic control, demonstrating the multifaceted benefits of these medications [27] [28].

Gestational diabetes patients responded well to metformin and insulin, with rapid normalization of fasting blood glucose and HbA1c levels, which is crucial for preventing adverse pregnancy outcomes. HbA1c served as a consistent and reliable indicator of long-term glucose control across all subtypes, with 85% of patients showing significant reductions following treatment.

Additionally, novel biomarkers like visfatin and serum amyloid A (SAA) were elevated in a subset of T2DM patients with severe insulin resistance, indicating potential pathways for future

targeted therapies. These markers may help identify patients at higher risk for complications and guide the development of more personalized anti-inflammatory or metabolic interventions. Despite these promising results, about 15% of patients did not experience marked improvement, largely due to non-adherence or the presence of complex comorbidities. This highlights the importance of integrating patient education and long-term monitoring into treatment plans. Overall, this study reinforces the value of tailoring diabetes treatment to individual biomarker profiles, offering a more precise and effective approach to managing this diverse and complex disease.

Conclusion

This study highlights the value of biomarker-based strategies in improving diabetes management through personalized treatment. Biomarkers such as C-peptide and GAD antibodies improve diagnostic accuracy by distinguishing between T1DM and T2DM. Tailored therapies based on HbA1c levels support better glycaemic control, while interventions targeting triglycerides and LDL reduce cardiovascular risk. Inflammatory markers like visfatin and SAA provide insights into systemic inflammation, guiding anti-inflammatory treatment choices. The results showed improved outcomes in glycaemic control, lipid profile, and inflammation for most patients. However, around 15% showed limited improvement, mainly due to poor adherence. Future directions include investigating new biomarkers, applying AI-based tools to refine individualized care, and conducting long-term studies to assess sustained treatment effectiveness.

Source of Funding: This research received no external funding

Conflict of Interest: The authors have no conflict of interest.

Ethical Clearance The samples were gained according to Local Research Ethics Committee Approval in the College of Science, University of Diyala, No. 25 EC-62 in 9/2/2025

References

[1] H. B. Felicia, N. E. Adler, S. A. Berkowitz, M. H. Chin, T. L. Gary-Webb, A. Navas-Acien, P. L. Thornton, and D. Haire-Joshu, Social Determinants of Health and Diabetes: A Scientific Review, PubMed Central, 44(1) 258–279(2020), DOI(https://doi.org/10.2337/dci20-0053)

[2] A. Boles, R. Kandimalla and P. H. Reddy, Dynamics of diabetes and obesity: Epidemiological perspective, Biochimica et Biophysica Acta (BBA) - Molecular Basis of Disease, 1863(5), 1026-1036(2017), DOI(https://doi.org/10.1016/j.bbadis.2017.01.016)

[3] A. Antar, N. A. Ashour, M. Sharaky, M. Khattab, N. A. Ashour, R. T. Zaid, E. J. Roh, A. A. Al-Karmalawy and A. Elkamhawy, Diabetes mellitus: Classification, mediators, and complications; A gate to identify potential targets for the development of new effective treatments, Biomedicine & Pharmacotherapy, 168, (2021), DOI(https://doi.org/10.1016/j.biopha.2023.115734)

[4] J. Raffin, P. d. Souto, A. P. Le Traon, B. Vellas, M. A. Leheudre and Y. Rolland, Sedentary behavior and the biological hallmarks of aging, Ageing Research Reviews, 83, (2023), DOI(https://doi.org/10.1016/j.arr.2022.101807)

[5] V. S. S. Nishad, D. Dongare, A. C. Pati Tripathi, T. Tripathi and P. Tripathi, Deciphering the intricacies of immune system dysfunction and its impact on diabetes mellitus: Revisiting the communication strategies to manage diabetes mellitus, Health Sciences Review, 13, (2024), DOI(https://doi.org/10.1016/j.hsr.2024.100201)

[6] X. Cheng, X. Meng, R. Chen, Z. Song, S. Li, S. Wei, H. Lv, S. Zhang, H. Tang, Y. Jiang and R. Zhang, The molecular subtypes of autoimmune diseases, Computational and Structural Biotechnology Journal, 23, 1348-1363(2024), DOI(https://doi.org/10.1016/j.csbj.2024.03.026)

[7] A. A. Choudhury, and V. Devi Rajeswari, Gestational diabetes mellitus - A metabolic and reproductive disorder, Biomedicine & Pharmacotherapy, 143, (2021), DOI(https://doi.org/10.1016/j.biopha.2021.112183)

[8] M. Puccetti, Marilena Pariano, Aurélie Schoubben, Stefano Giovagnoli and Maurizio Ricci, Biologics, theranostics, and personalized medicine in drug delivery systems, Biologics, theranostics, and personalized medicine in drug delivery systems, 201, (2024), DOI(https://doi.org/10.1016/j.phrs.2024.107086)

[9] A. S. Cruz, A. Mendes-Frias, A. I. Oliveira, L. Dias, A. R. Matos, A. Carvalho, C. Capela, J. Pedrosa, A. G. Castro and R. Silvestre, Interleukin-6 Is a Biomarker for the

Development of Fatal Severe Acute Respiratory Syndrome Coronavirus 2 Pneumonia, Frontiers in immunology, 12, (2021), DOI(https://doi.org/10.3389/fimmu.2021.613422)

[10] M. Ortiz-Martínez, M. González-González, AJ. Martagón, V. Hlavinka, RC. Willson and M. Rito-Palomares, Recent Developments in Biomarkers for Diagnosis and Screening of Type 2 Diabetes Mellitus, Curr Diab Rep, 22(3), 95-115(2022), DOI(https://doi.org/10.1007/s11892-022-01453-4)

[11] G. E. Grieco, Z. M. Besharat, G.Licata, D. Fignani, N. Brusco, L. Nigi, C. Formichi, A. Po, C. Sabato, A. Dardano, A. Natali, F. Dotta, G. Sebastiani, and E. Ferretti, Circulating microRNAs as clinically useful biomarkers for Type 2 Diabetes Mellitus: miRNomics from bench to bedside, Translational Research, 247, 137-157(2022), DOI(https://doi.org/10.1016/j.trsl.2022.03.008)

[12] M. Jabara, O. Kose, G. Perlman, S. Corcos, and M. Ant, Artificial Intelligence-Based Digital Biomarkers for Type 2 Diabetes: A Review, Canadian Journal of Cardiology, 40(10), 1922-1933(2024), DOI(https://doi.org/10.1016/j.cjca.2024.07.028)

[13] H. Kaur, A.V. Raveendran, S. Athwal, M. Verma, V. Mutreja, K. E. Ukhurebor, and H. S. Kusuma, Assessment of diabetes biomarker monitoring via novel biosensor activity, Results in Chemistry, 5, (2023), DOI(https://doi.org/10.1016/j.rechem.2023.100777)

[14] H. Breiteneder, Y. Q. Peng, I. Agache, Z. Diamant, T. Eiwegger, W. J. Fokkens, C. Traidl-Hoffmann, K. Nadeau, R. E. O'Hehir, L. O'Mahony, O. Pfaar, M. J. Torres, D. Y. Wang, L. Zhang, and C. A. Akdis, Biomarkers for diagnosis and prediction of therapy responses in allergic diseases and asthma, Allergy, 75(12), 3039–3068(2020), DOI(https://doi.org/10.1111/all.14582)

[15] T. Litman, Personalized medicine—concepts, technologies, and applications in inflammatory skin diseases, Acta pathologica microbiologica et immunologica Scandinavica, 127(5), 386-424(2019), DOI(https://doi.org/10.1111/apm.12934)

[16] C. Ciurtin, G. A. Helmy , A. C. Ferreira, J. J. Manson , E. C. Jury, and T. McDonnell, A tale of two functions: C-reactive protein complement-ary structures and, Clinical Immunology, 265(2024), DOI(https://doi.org/10.1016/j.clim.2024.110281)

[17] C. Luna-Marco, F. Iannantuoni, A. Hermo-Argibay, D. Devos, J. D. Salazar, V. M. Víctor, and S. Rovira-Llopis, Cardiovascular benefits of SGLT2 inhibitors and GLP-1 receptor agonists through effects on mitochondrial function and oxidative stress, Free Radical Biology and Medicine, 213, 19-35(2024), DOI(https://doi.org/10.1016/j.freeradbiomed.2024.01.015)

[18] A. Elrakaybi, K. Laubner, Q. Zhou, M. J. Hug, and J. Seufert, Cardiovascular protection by SGLT2 inhibitors – Do anti-inflammatory mechanisms play a role?, 64, (2022), DOI(https://doi.org/10.1016/j.molmet.2022.101549)

[19] H. Chehregosha, M. E. Khamseh, M. Malek, F. Hosseinpanah, and F. Ismail-Beigi, A View Beyond HbA1c: Role of Continuous Glucose Monitoring, Diabetes Therapy, 10, 853–863(2019), DOI(https://doi.org/10.1007/s13300-019-0619-1)

[20] J. Sztabkowska, Milena, B. Głowińska-Olszewska, and A. Bossowski, C-peptide and residual β-cell function in pediatric diabetes–state of the art, Pediatric Endocrinology Diabetes and Metabolism, 27(2), 123-133(2021), DOI(https://doi.org/10.5114/pedm.2021.107165)

[21] E. K. Duran, A. W. Aday, N. R. Cook, J. E. Buring, P. M. Ridker, and A. D. Pradhan, Triglyceride-Rich Lipoprotein Cholesterol, Small Dense LDL Cholesterol, and Incident Cardiovascular Disease, Journal of the American College of Cardiology, 75(17), 2122–2135(2020), DOI(https://doi.org/10.1016/j.jacc.2020.02.059)

[22] C. E. Kosmas, R. Polanco, S. Bousvarou, M. D. Papakonstantinou, E. J. Peña Genao, E. Guzman, C. E. Kostara, The Triglyceride/High-Density Lipoprotein Cholesterol (TG/HDL-C) Ratio as a Risk Marker for Metabolic Syndrome and Cardiovascular Disease, Diagnostics, 13(5), (2023), DOI(https://doi.org/10.3390/diagnostics13050929)

[23] A. Aulanni'am, D. K. Wuragil, H. Susanto, A. Herawati, Y. M. Nugroho, W. N.Laili Fajri, P. F. Putri, S. Susiati, J. D. T. Purnomo, A. Taufiq, and D. W. Soeatmadji, The early detection of type 1 diabetes mellitus and latent autoimmune diabetes in adults (LADA) through rapid test reverse-flow immunochromatography for glutamic acid decarboxylase 65 kDa (GAD65), Heliyon, 8(1), (2022)

[24] G. F. Hassan, and M. J. A. Al-Imari, Anti-Glutamic acid Decarboxylase Autoantibody as Biomarker for Diagnosis of Type 1DM Patients in Iraq, Indian Journal of Public Health Research & Development, 10(2), 778-783(2019)

[25] A. MMI, Role of visfatin in obesity-induced insulin resistance, World journal of clinical cases, 10(30), 10840–10851(2022), DOI(https://doi.org/10.12998/wjcc.v10.i30.10840)

[26] S. A. A. Rabo, N. A. Mohammed, S. S. Eissa, A. A. Ali, S. M. Ismail, and R. S. Gad, Serum visfatin in type 2 diabetes mellitus, Egyptian Journal of Internal Medicine, 27-32(2013), DOI(https://doi.org/10.7123/01.EJIM.0000425961.54125.23)

[27] P. Bjornstad, M. Schäfer, U. Truong, M. Cree-Green, L. Pyle , A. Baumgartner, Y. G. Reyes , A. Maniatis, S. Nayak , R. P. Wadwa, L. P. Browne, J. E. B. Reusch, and K. J. Nadeau, Metformin Improves Insulin Sensitivity and Vascular Health in Youth With Type 1 Diabetes Mellitus: Randomized Controlled Trial, Circulation, 138(25), 2895-2907(2018), DOI(https://doi.org/10.1161/CIRCULATIONAHA.118.035525)

[28] Y. Chen, F. Gu, J. Guan, and Y. Ji, Metformin Might Inhibit Virus through Increasing Insulin Sensitivity, Chinese Medical Journal, 131(3), 376-377(2018), DOI(https://doi.org/10.4103/0366-6999.223856)

[29] M. Guo, J. Gu, F. Teng, J. Chen, X. Ma, Q. Chen, Y. Pu, Z. Jiang, Y. Long, and Y. Xu, The efficacy and safety of combinations of SGLT2 inhibitors and GLP-1 receptor agonists in the treatment of type 2 diabetes or obese adults: a systematic review and meta-analysis, Endocrine, 67, 294–304(2020), DOI(https://doi.org/10.1007/s12020-019-02175-6)

[30] E. Brown, J. P. H. Wilding, T. M. Barber, U. Alam, and D. J. Cuthbertson, Weight loss variability with SGLT2 inhibitors and GLP-1 receptor agonists in type 2 diabetes mellitus and obesity: Mechanistic possibilities, Obesity Reviews, 20(6), 816-828(2019), DOI(https://doi.org/10.1111/obr.12841)

[31] C. F. Deacon, Dipeptidyl peptidase 4 inhibitors in the treatment of type 2 diabetes mellitus, Nature Reviews Endocrinology, 16(11), 642-653(2020), DOI(https://doi.org/10.1038/s41574-020-0399-8)

[32] K. Makrilakis, The role of DPP-4 inhibitors in the treatment algorithm of type 2 diabetes mellitus: when to select, what to expect, International journal of environmental research and public health, 16(15), 2720(2019), DOI(https://doi.org/10.3390/ijerph16152720)

[33] G. A. Nichols, S. Philip, K. Reynolds, C. B. Granowitz, and S. Fazio, Increased Cardiovascular Risk in Hypertriglyceridemic Patients With Statin-Controlled LDL Cholesterol, The Journal of Clinical Endocrinology & Metabolism, 103(8), 3019–3027(2018), DOI(https://doi.org/10.1210/jc.2018-00470)

[34] A. K. Shrivastava, H. V. Singh, A. Raizada, S. K. Singh, A. Pandey, N. Singh, D. S. Yadav, and H. Sharma, Inflammatory markers in patients with rheumatoid arthritis, Allergologia et Immunopathologia, 43(1), 81-87(2015), DOI(https://doi.org/10.1016/j.aller.2013.11.003)

[35] D. M.Giudice, and S. W. Gangestad, Rethinking IL-6 and CRP: Why they are more than inflammatory biomarkers, and why it matters, Brain, behavior, and immunity, 70(1), 61-75(2018), DOI(https://doi.org/10.1016/j.bbi.2018.02.013)

[36] A. S. Alexopoulos, A. Qamar, K. Hutchins, M. J. Crowley, B. C. Batch, and J. R. Guyton, Triglycerides: emerging targets in diabetes care? Review of moderate hypertriglyceridemia in diabetes, Current diabetes reports, 1-11(2019), DOI(https://doi.org/10.1007/s11892-019-1136-3)

[37] T. V. Rohm, D. T. Meier, J. M. Olefsky, and M. Y. Donath, Inflammation in obesity, diabetes, and related disorders, Immunity, 55(1), 31-55(2022)

[38] L. M. Jacobsen, and D. Schatz, Immunotherapy-based strategies for treatment of type 1 diabetes, Hormone Research in Paediatrics, 1-19(2024), DOI(https://doi.org/10.1159/000542002)