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Review Article

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RECENT ADVANCES IN THE DIAGNOSIS AND MANAGEMENT OF TYPE 2 DIABETES MELLITUS: A NARRATIVE REVIEW

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Abstract: Type 2 diabetes mellitus (T2DM) is a chronic metabolic disorder characterized by insulin resistance, impaired insulin secretion, and persistent hyperglycemia. Its rising global prevalence has become a major public health concern due to its association with cardiovascular disease, chronic kidney disease, neuropathy, retinopathy, and other long-term complications. Recent advances in the diagnosis and management of T2DM have improved early detection, individualized treatment, and clinical outcomes. Advances in diagnosis include the use of glycated hemoglobin (HbA1c), continuous glucose monitoring (CGM), flash glucose monitoring, and novel biomarkers, which have enhanced diagnostic accuracy and glycemic assessment. Therapeutic developments, particularly sodium-glucose cotransporter-2 (SGLT2) inhibitors, glucagon-like peptide-1 (GLP-1) receptor agonists, and dual GIP/GLP-1 receptor agonists, have transformed diabetes management by improving glycemic control while providing cardiovascular, renal, and weight-loss benefits. This narrative review summarizes recent advances in the diagnosis and management of T2DM and highlights their clinical significance in improving patient care and reducing the burden of diabetes.

Keywords: *Diabetes mellitus, type 2 DM, diagnosis, management, GLP-1 Receptor agonist,SGLT2 inhibitor, continuous glucose monitoring.*

INTRODUCTION

Diabetes Mellitus, commonly called DM, is a chronic metabolic disorder characterized by elevated blood glucose levels due to defects in insulin secretion, insulin action, or both [1]. The main types are Type 1 DM - an autoimmune destruction of pancreatic β-cells, and Type 2 DM - insulin resistance with relative insulin deficiency [2]. If uncontrolled, it can lead to complications affecting the eyes, kidneys, heart, nerves, and blood vessels. Early diagnosis, lifestyle modification, and proper medication are key to preventing long-term complications [3].

Type 1 diabetes mellitus (T1DM) is a chronic autoimmune metabolic disorder characterized by the immune-mediated destruction of the insulin-producing pancreatic β-cells, resulting in absolute insulin deficiency and persistenthyperglycemia [4]. It typically develops during childhood or adolescence but can occur at any age. Patients with T1DM require lifelong insulin therapy for survival [5].

Type 2 diabetes mellitus (T2DM) is a chronic, progressive metabolic disorder characterized by insulin resistance and progressive pancreatic β-cell dysfunction, leading to relative insulin deficiency and persistent hyperglycemia [6]. It is the most common form of diabetes, accounting for approximately 90–95% of all diabetes cases worldwide. T2DM is strongly associated with obesity, physical inactivity, genetic predisposition, and unhealthy lifestyle factors and is managed through lifestyle modification, pharmacotherapy, and, in some cases, insulin therapy [7].

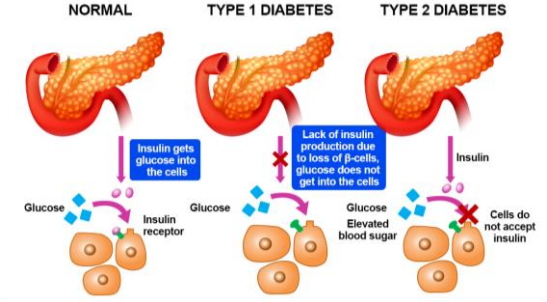

Figure 01: Stage of Diabetes Mellitus

Gestational diabetes mellitus (GDM) is glucose intolerance that is first diagnosed during pregnancy. It develops when pregnancy-induced insulin resistance cannot be adequately compensated by increased insulin secretion from pancreatic β-cells, resulting in hyperglycemia [8]. GDM affects approximately 10–15% of pregnancies worldwide and is associated with adverse maternal and fetal outcomes. Women with GDM and their offspring are at an increased risk of developing Type 2 diabetes mellitus (T2DM) later in life [9].

EPIDEMIOLOGY: Diabetes mellitus (DM) is one of the fastest-growing non-communicable diseases worldwide and represents a major public health challenge [10]. According to the International Diabetes Federation (IDF) Diabetes Atlas, 11th edition (2025), an estimated 588.7 million adults (20–79 years) were living with diabetes in 2024, corresponding to a global prevalence of 11.1% (approximately 1 in 9 adults).This marks a substantial increase from 537 million adults reported in 2021. If current trends continue, the global number of adults with diabetes is projected to reach 852.5 million by 2050, representing a 45% increase over the next 25 years [10, 11].

Global trend in adults living with diabetes

Estimated number of adults (20–79 years) living with diabetes worldwide.

Diabetes Need for recent advances

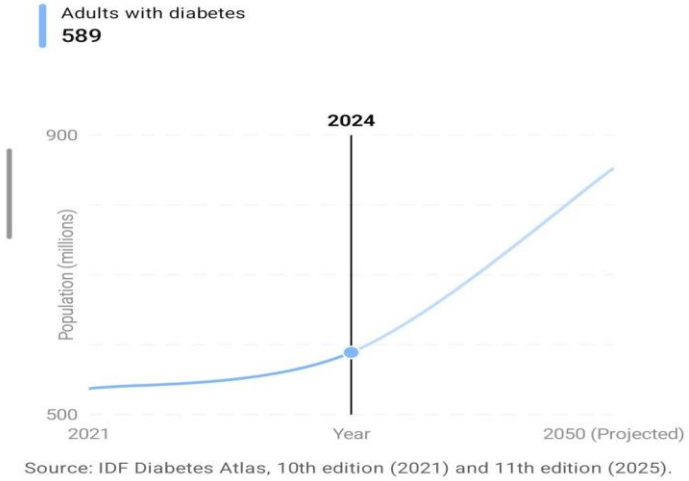

Figure 02: Diabetes Atlas of 10th and 11th Edition

Earlier diabetes treatment mainly aimed to control blood sugar. However, research showed that many patients with diabetes die from cardiovascular disease or develop kidney failure, even when blood glucose is reasonably controlled [12]. Large clinical trials demonstrated that SGLT2 inhibitors and GLP-1 receptor agonists not only lower blood glucose but also protect the heart and kidneys and improve survival. Therefore, current guidelines recommend choosing these drugs based on a patient's overall health and risk profile rather than focusing only on HbA1c [13].

- ✓ Rising global prevalence of diabetes.
- ✓ Decrease in diabetes-related complications (cardiovascular disease, kidney disease, neuropathy, retinopathy).
- ✓ Limitations of conventional therapies (hypoglycemia, weight gain, inadequate glycemic control).
- ✓ Need for better long-term blood glucose management.
- ✓ Prevention of cardiovascular and renal complications.
- ✓ Improved weight management and potential diabetes remission.
- ✓ Development of safer drugs with fewer adverse effects.
- ✓ Personalized, patient-centered treatment approaches.
- ✓ Improved quality of life and treatment adherence [14].

RECENT ADVANCES IN DIAGNOSIS

1. **Continuous Glucose Monitoring (CGM) expansion (2021–2025):** CGM is now recommended for more people with T2DM, including those using basal insulin and, in some cases, non-insulin therapies. Newer devices (e.g., Dexcom G7, FreeStyle Libre 3) are smaller, more accurate, and provide real-time glucose data [15].
2. **Updated ADA diagnostic guidance (2024–2025):** Greater emphasis on using HbA1c together with plasma glucose when results are inconsistent. More attention to conditions where HbA1c may be unreliable (anemia, kidney disease, hemoglobin variants) [16].
3. **Artificial Intelligence (AI):**

AI algorithms are increasingly used to predict T2DM risk, identify undiagnosed diabetes from electronic health records, and detect complications such as diabetic retinopathy [17].

4. Novel biomarkers (research stage): Studies from 2021–2025 have identified promising biomarkers such as microRNAs (miRNAs), metabolomic markers, inflammatory markers, and gut microbiome signatures for earlier diagnosis and prediction of T2DM.
These are not yet part of routine clinical practice [18].
5. Point-of-care HbA1c devices: Portable HbA1c analyzers have become more accurate and are increasingly used in primary care and remote settings [19].
6. Non-invasive glucose monitoring
Smartwatches, wearable patches, Raman spectroscopy, and sweat- or saliva-based sensors have made significant research progress between 2022 and 2025.Most are still under clinical evaluation and are not standard diagnostic tools [20].

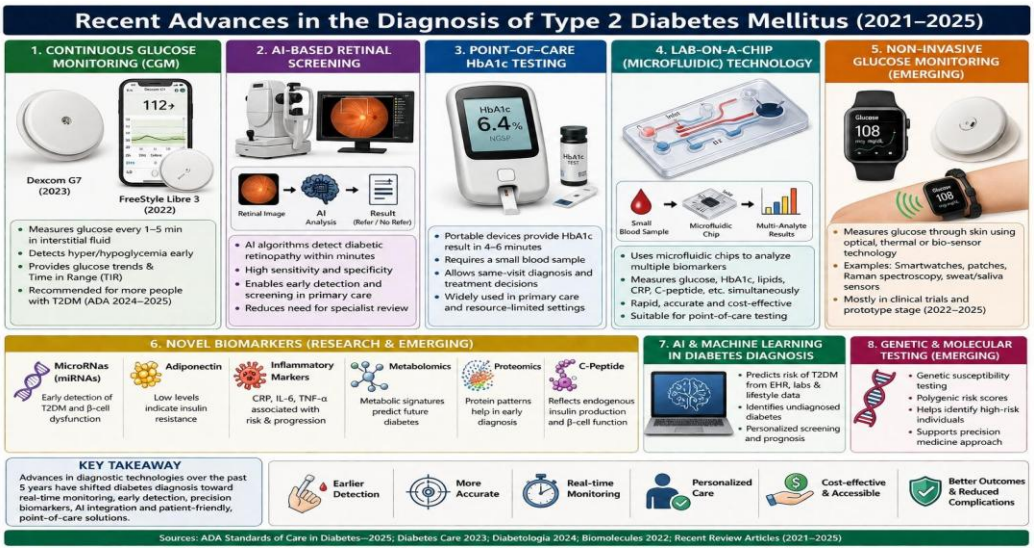

Figure 03: Recent advances in the Diagnosis of type 2 DM.

RECENT ADVANCES IN TYPE 2 DIABETES TREATMENTS (2024–2025):
Recent advances in the treatment of type 2 diabetes mellitus (T2DM) have shifted the focus beyond blood glucose control to protecting the heart and kidneys. According to the 2025 diabetes care guidelines, GLP-1 receptor agonists (e.g., semaglutide, dulaglutide, liraglutide) and SGLT2 inhibitors are recommended not only to lower blood sugar but also to reduce cardiovascular events and slow chronic kidney disease progression, even in patients with well-controlled HbA1c.[21] Tirzepatide, the first dual GIP/GLP-1 receptor agonist, has shown greater reductions in HbA1c and body weight than traditional GLP-1 drugs. In addition, higher-dose oral semaglutide provides an effective tablet alternative to injections, improving patient convenience and treatment adherence. These innovations support a more personalized approach to diabetes management, leading to better long-term outcomes and improved quality of life. [22]
The figure compares the evolution of Type 2 diabetes mellitus (T2DM) management from before 2018 to the 2023 recommendations. Before 2018, treatment mainly focused on lowering blood glucose, with metformin used as the first-line drug, followed by a stepwise progression from monotherapy to dual therapy, triple therapy, and finally insulin if HbA1c targets were not achieved. [23]
In contrast, the 2023 recommendations emphasize a personalized, patient-centered approach, considering cardiovascular disease, heart failure, chronic kidney disease, and weight management when selecting therapy. While metformin remains an important medication, it is no longer mandatory as the first-line treatment for all patients. Greater importance is also given to GLP-1 receptor agonists and SGLT2 inhibitors, along with healthy lifestyle measures and early combination therapy to improve glycemic control and provide cardiovascular and renal protection [24]. The latest ADA/EASD guidelines recommend individualized treatment based on comorbidities, patient preferences, and risk factors rather than relying solely on HbA1c targets.

1. SGLT2 Inhibitors

SGLT2 inhibitors (empagliflozin, dapagliflozin, canagliflozin) are among the most significant advances in T2DM treatment. These agents reduce renal glucose reabsorption, promoting urinary glucose excretion and lowering blood glucose independent of insulin. Beyond glycemic control, they reduce hospitalization for heart failure, slow chronic kidney disease progression, lower blood pressure, and promote modest weight loss, making them preferred agents for patients with cardiovascular disease or chronic kidney disease [25].

2. GLP-1 Receptor Agonists

GLP-1 receptor agonists (semaglutide, liraglutide, dulaglutide) improve glycemic control by stimulating glucose-dependent insulin secretion, suppressing glucagon release, delaying gastric emptying, and increasing satiety. These drugs

produce substantial weight loss and reduce the risk of major adverse cardiovascular events, making them first-line options in patients with obesity or established cardiovascular disease [26].

3. Dual GIP/GLP-1 Receptor Agonist (Tirzepatide)

Tirzepatide is the first dual glucose-dependent insulinotropic polypeptide (GIP) and GLP-1 receptor agonist. Clinical trials have demonstrated greater reductions in HbA1c and body weight than conventional GLP-1 receptor agonists, representing a major breakthrough in the treatment of T2DM and obesity [27].

4. Early Combination and Personalized Therapy

Current guidelines recommend initiating combination therapy earlier in selected patients instead of waiting for treatment failure with metformin alone. Drug selection is individualized according to the presence of atherosclerotic cardiovascular disease, heart failure, chronic kidney disease, obesity, hypoglycemia risk, and patient preferences [28].

5. Weight-Centered Management

Weight reduction is now considered a primary therapeutic target. Lifestyle intervention remains essential, while GLP-1 receptor agonists, tirzepatide, anti-obesity medications, and metabolic (bariatric) surgery are increasingly used to achieve sustained weight loss and improve metabolic outcomes [29].

6. Continuous Glucose Monitoring (CGM) and Digital Health

The use of continuous glucose monitoring, telemedicine, mobile health applications, and artificial intelligence-assisted diabetes care has expanded. These technologies improve glycemic monitoring, medication adherence, patient education, and treatment optimization, particularly in insulin-treated patients [30].

7. Organ-Protective Therapy

Modern T2DM management emphasizes prevention of cardiovascular and renal complications. SGLT2 inhibitors and GLP-1 receptor agonists are now prescribed not only for glucose lowering but also for their proven ability to reduce cardiovascular events, preserve kidney function, and improve survival [31].

Tirzepatide

- First dual GIP/GLP-1 receptor agonist approved for the treatment of T2DM.
- Administered as a once-weekly subcutaneous injection.
- Improves blood glucose control by increasing insulin secretion and reducing glucagon release during hyperglycemia.
- Produces greater HbA1c reduction than semaglutide and long-acting insulin analogs.
- Promotes significant weight loss, improving metabolic health [32].
- Provides better glycemic control with a low risk of hypoglycemia when used appropriately.
- Convenient once-weekly dosing improves patient adherence.
- Represents a major advancement in personalized and effective management of type 2 diabetes mellitus [33].

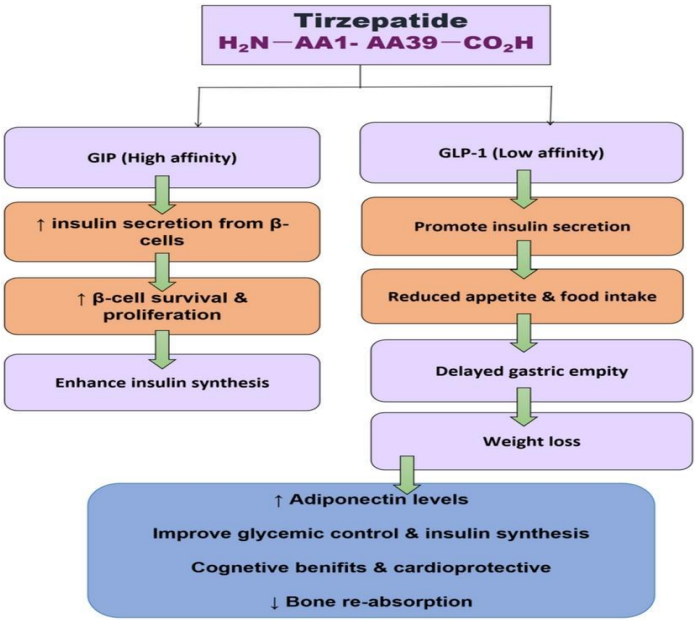

Figure 04: Proposed mechanism of action of tirzepatide

CONCLUSION

Recent advances in the treatment of type 2 diabetes mellitus (T2DM) have shifted the focus beyond glycemic control to improving cardiovascular, renal, and metabolic outcomes. While metformin remains the first-line therapy, newer agents such as SGLT2 inhibitors and GLP-1 receptor agonists provide effective glucose lowering, promote weight loss, and reduce cardiovascular and kidney complications. Novel therapies like tirzepatide and emerging triple incretin agonists show even greater benefits in glycemic control and weight reduction. These advancements support a personalized treatment approach, improving overall patient outcomes and quality of life.

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CONFLICT OF INTEREST

Nil

INFORMED CONSENT

Not applicable

ETHICAL STATEMENT

Not Applicable.

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