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Therapeutic interventions for controlling pregnancy-induced diabetes mellitus: An overview

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Abstract
Pregnancy-induced diabetes mellitus, commonly known as gestational diabetes mellitus (GDM), affects approximately 7-14% of pregnancies globally and is associated with increased risks of maternal and fetal complications. This review provides an overview of therapeutic interventions for controlling GDM, emphasizing lifestyle modifications, pharmacological treatments, and precision approaches. Lifestyle interventions, including diet and exercise, serve as first-line therapy, effectively managing glycemia in 70-85% of cases. Pharmacological options, primarily insulin and metformin, are used when lifestyle measures are insufficient. Emerging precision strategies tailor interventions based on individual markers like BMI and glucose levels. Evidence from systematic reviews and guidelines supports these approaches in reducing adverse outcomes, though long-term postpartum adherence remains a challenge. Future directions include integrated models for sustained management and further research on personalized therapies.

Keywords: Gestational diabetes mellitus, pregnancy-induced diabetes, medical nutrition therapy, low-glycemic index diet, chrononutrition, lifestyle modification, insulin therapy, metformin, fetal outcomes, macrosomia, preeclampsia

Introduction

Gestational diabetes mellitus (GDM) is defined as any degree of glucose intolerance with onset or first recognition during pregnancy, typically in the second or third trimester (American Diabetes Association, 2025; Chatterjee and Tewari, 2025) [12, 44]. It arises from inadequate pancreatic beta-cell response to pregnancy-induced insulin resistance, driven by placental hormones such as human placental lactogen, growth hormone, and progesterone (Plows *et al*., 2018) [36]. Epidemiologically, GDM complicates about 7–10% of U.S. pregnancies and up to 14–18% worldwide, with higher prevalence in high-risk ethnic groups (e.g., Asian, Hispanic/Pacific Islander, African American) (American Diabetes Association, 2025; Sweeting *et al*., 2024) [41, 44]. Risk factors include obesity (BMI ≥30 kg/m²), previous GDM, family history of diabetes, advanced maternal age, multiparity, and polycystic ovary syndrome (American Diabetes Association, 2025) [44].

Diagnosis involves screening at 24–28 weeks gestation using either the one-step 75-g oral glucose tolerance test (OGTT) or the two-step approach (50-g glucose challenge followed by 100-g OGTT if abnormal) (American Diabetes Association Professional Practice Committee, 2026; Will, 2023; Sweeting *et al*., 2022) [2, 40, 49]. Early screening is recommended for high-risk individuals (American Diabetes Association Professional Practice Committee, 2026; Kaymak, 2025) [2, 23]. Untreated GDM increases risks of macrosomia, preeclampsia, cesarean delivery, neonatal hypoglycemia, and long-term maternal type 2 diabetes (T2D) risk (up to 10-fold higher) (American Diabetes Association Professional Practice Committee, 2026 [2]; Ye *et al*., 2022; Sweeting *et al*., 2022) [40]. Therapeutic interventions aim to achieve euglycemia and mitigate these complications (American Diabetes Association Professional Practice Committee, 2026; Sweeting *et al*., 2022; Nakshine & Dalal, 2023) [2, 31, 40].

Therapeutic Interventions

Therapeutic strategies for GDM focus on lifestyle modifications as first-line treatment, escalating to pharmacotherapy if needed (American Diabetes Association Professional Practice Committee, 2026; World Health Organization, 2025; Sweeting *et al*., 2022) [2, 40, 50]. Guidelines from the American Diabetes Association (ADA) and others emphasize individualized management (American Diabetes Association Professional Practice Committee, 2026; World Health Organization, 2025; Tewari *et al*., 2025; Mohan, 2024; Will, 2023) [2, 12, 30, 49, 50].

Lifestyle Interventions

Lifestyle changes, including medical nutrition therapy (MNT) and physical activity, are recommended for all women with GDM and can control glycemia in the majority of cases (American Diabetes Association Professional Practice Committee, 2026; Cheong *et al*., 2025; Shepherd *et al*., 2017) [2, 13, 38].

Dietary Interventions

MNT involves an individualized plan developed with a registered dietitian, emphasizing nutrient-dense foods like fruits, vegetables, whole grains, and healthy fats while limiting processed items (American Diabetes Association Professional Practice Committee, 2026; Cheong *et al*., 2025) [2, 13]. Low-glycemic index (LGI) diets reduce gestational weight gain (GWG) and improve glycemic control, particularly when culturally tailored (Viana *et al*.,

2014; Wei *et al*., 2016; Deng *et al*., 2023 [16, 43, 47]; Di *et al*., 2025). Recommendations include at least 175 g carbohydrates, 71 g protein, and 28 g fiber daily, with meals distributed as three small-to-moderate portions and 2-3 snacks (American Diabetes Association Professional Practice Committee, 2026) [2]. Chrononutrition, aligning meal timing with circadian rhythms (e.g., avoiding high-carb evening intake), enhances metabolic responses (Xega, 2025; Messika *et al*., 2022; Boege *et al*., 2025) [8, 29, 51].

Exercise Interventions

Moderate-intensity aerobic or resistance exercise (150 minutes/week) improves glucose control, reduces insulin requirements, and lowers GDM incidence in preventive settings (American Diabetes Association Professional Practice Committee, 2026; Niu, 2025; Xie *et al*., 2024) [2, 33, 52]. Supervised programs following FITT-VP principles (frequency, intensity, time, type, volume, progression) show high adherence during pregnancy but decline postpartum (Niu, 2025) [33]. Combined diet-exercise approaches yield superior outcomes, reducing macrosomia and preterm birth risks (Shepherd *et al*., 2017; Zhang *et al*., 2024; Cui *et al*., 2025) [15, 38, 56].

Supplements and Other Non-Pharmacological: Myo-inositol reduce GDM risk in high-risk women, while probiotics show limited efficacy. Sleep hygiene supports glycemic control when integrated with chrononutrition.

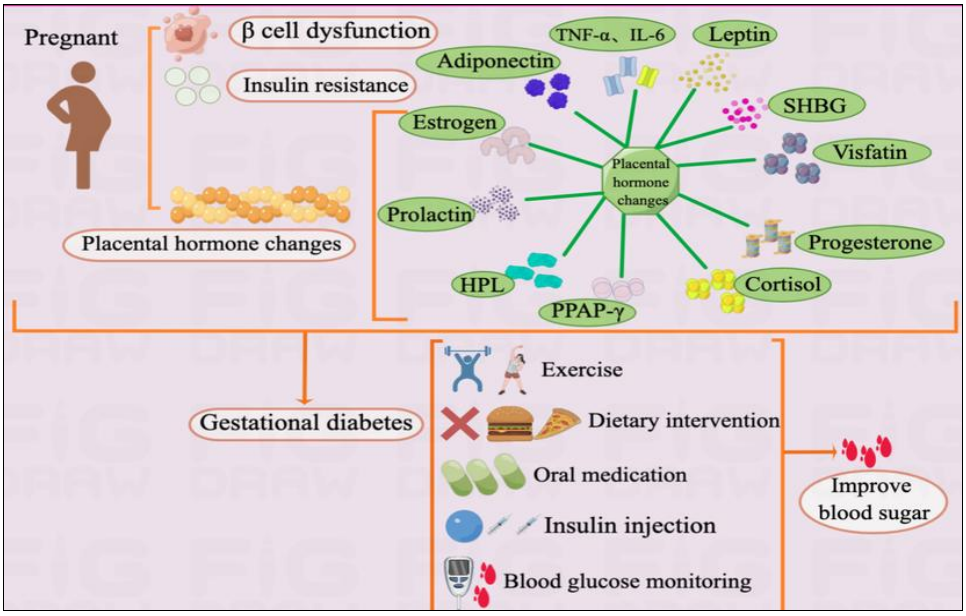

Fig 1: Pathophysiological Mechanisms of Gestational Diabetes Mellitus and Its Management Strategies

Pharmacological Interventions

When lifestyle measures fail to achieve targets (fasting <95 mg/dL, 1-hour postprandial <140 mg/dL, 2-hour <120 mg/dL), pharmacotherapy is initiated.

Insulin: First-line agent, as it does not cross the placenta. Regimens include basal-bolus injections or pumps, dosed by weight and gestation (e.g., 0.7-1.0 units/kg/day total).

Oral Agents: Metformin (500-2500 mg/day) is an alternative if insulin is declined, though it crosses the placenta and may increase preterm birth risk. Glyburide is not recommended first-line due to neonatal risks.

Monitoring and Self-Management

Monitoring and self-management are integral components of effective gestational diabetes mellitus (GDM) care, enabling timely adjustments to dietary, lifestyle, and pharmacological interventions (American Diabetes Association Professional Practice Committee, 2026; Chai, 2025) [2, 11]. Self-monitoring of blood glucose (SMBG), typically performed four times daily (fasting and postprandial), remains the cornerstone for assessing glycemic control and ensuring adherence to recommended targets (American Diabetes Association Professional Practice Committee, 2026; World Health Organization, 2025) [2, 50]. Advances in digital health have enhanced SMBG effectiveness through telehealth platforms, mobile applications, and remote/continuous glucose monitoring systems, which facilitate real-time data sharing, prompt clinical feedback, and individualized counseling (El Seifi, 2024; Wang, 2025; Linder *et al*., 2026) [19, 26, 44]. These approaches have been associated with improved glycemic outcomes, reduced need for insulin escalation, and greater patient engagement (Battarbee, 2024; Burk *et al*., 2025; Chai, 2025) [5, 10, 11]. Additionally, community-based and peer-supported programs play a critical role in reinforcing self-management behaviors by improving health literacy, cultural acceptability, and sustained adherence, particularly in resource-limited settings (Merchant, 2025; Guo *et al*., 2024; Azmiardi *et al*., 2021) [4, 22, 28]. Collectively, structured monitoring combined with supportive self-management frameworks strengthens continuity of care and optimizes maternal and fetal outcomes in GDM (American Diabetes Association Professional Practice Committee, 2026; Shepherd *et al*., 2017; Wang, 2025) [2, 38, 44].

Precision Approaches

Precision approaches in the management of gestational diabetes mellitus emphasize individualized care based on maternal phenotypic and metabolic characteristics to optimize therapeutic outcomes (Benham *et al*., 2023; White,

2023; Athanasiadou *et al*., 2025) [3, 7, 48]. Clinical markers such as pre-pregnancy body mass index (BMI), history of previous GDM, fasting and post-load OGTT values, gestational weight gain patterns, and insulin resistance indices are increasingly used to stratify risk and predict the intensity of intervention required (Benham *et al*., 2023; Cooray *et al*., 2022; Yang *et al*., 2025) [7, 14, 53]. This stratification enables early identification of women likely to benefit from more aggressive lifestyle modification or timely pharmacotherapy (Benham *et al*., 2023; White, 2023) [7, 48]. Tailored medical nutrition therapy, culturally appropriate low-glycemic meal planning, and individualized exercise prescriptions aligned with metabolic profiles have been shown to improve glucolipid metabolism, enhance insulin sensitivity, and reduce excessive gestational weight gain (Luo *et al*., 2023; Pande *et al*., 2024; Dingena *et al*., 2023) [18, 27, 34]. By aligning interventions with individual risk profiles, precision-based strategies contribute to improved glycemic control, lower incidence of maternal and fetal complications, and more efficient resource utilization in GDM care (Benham *et al*., 2023; Athanasiadou *et al*., 2025; Wang *et al*., 2025) [3, 7, 44].

Table 1: Therapeutic Interventions for Gestational Diabetes Mellitus: Key Examples, Efficacy, and Evidence Quality

Intervention Type	Key Examples	Efficacy/Evidence	GRADE Level
Lifestyle (Diet)	LGI diets, chrononutrition	Reduces GWG, improves glycemia	Moderate
Lifestyle (Exercise)	Moderate aerobic, 150 min/week	Lowers GDM incidence by 37%	Moderate
Combined Lifestyle	Diet + Exercise	Superior for outcomes	Low-Moderate
Pharmacological (Insulin)	Basal-bolus regimens	First-line, effective control	High (A)
Pharmacological (Metformin)	500-2500 mg/day	Alternative, but crosses placenta	Low (A for use)
Supplements	Myo-inositol	Reduces risk in high-risk	Very Low

Maternal and Fetal Outcomes

Here is the revised paragraph with APA-style citations added. Citations are drawn from the most current guidelines and diverse high-quality sources, including systematic reviews, meta-analyses, and cohort studies (primarily 2022 [40]–2026) to substantiate the key claims on maternal/fetal outcomes, long-term risks, postpartum prevention, and breastfeeding benefits.

Effective management of gestational diabetes mellitus (GDM) through timely lifestyle and pharmacological interventions significantly improves both maternal and fetal outcomes (American Diabetes Association Professional Practice Committee, 2026 [2]; Ye *et al*., 2022; Lai *et al*., 2024) [24]. Optimal glycemic control reduces the incidence of fetal macrosomia, shoulder dystocia, neonatal hypoglycemia, and respiratory distress, while also lowering maternal risks of preeclampsia, excessive gestational weight gain, and operative or cesarean delivery (American Diabetes Association Professional Practice Committee, 2026 [2]; Ye *et al*., 2022; Nakshine & Dalal, 2023 [31]; StatPearls, 2025). Improved intrapartum glucose regulation contributes to better neonatal metabolic adaptation and decreased admission to neonatal intensive care units (Ye *et al*., 2022; Lai *et al*., 2024) [6, 24]. Despite resolution of hyperglycemia after delivery in most women, GDM confers a substantially elevated long-term risk of type 2 diabetes mellitus (T2D) and cardiometabolic disorders in mothers, as well as obesity and glucose intolerance in offspring (American Diabetes Association Professional Practice Committee, 2026; Nijs & Benhalima, 2020; Bendor *et al*., 2022; Al Bekai, 2025) [1, 2, 6, 32]. Evidence indicates that sustained postpartum lifestyle interventions, with or without metformin, can prevent or delay progression to T2D in approximately 35–40% of affected women (Ratner *et al*., 2008; Goveia *et al*., 2018; Wang *et al*., 2024; Bracco *et al*., 2025) [9, 21, 37, 46]. Additionally, exclusive and prolonged breastfeeding has been consistently associated with improved maternal insulin sensitivity and reduced future diabetes risk, underscoring the importance of continued postnatal follow-up and preventive strategies for both mother and child (Pinho-Gomes *et al*., 2021; Ley *et al*., 2020; Zheng *et al*., 2025 [25, 35, 57]; Flores-Quijano *et al*., 2024) [20].

Conclusion

Therapeutic interventions for controlling pregnancy-induced diabetes mellitus emphasize a stepwise, individualized approach aimed at achieving optimal glycemic control while safeguarding maternal and fetal health. Lifestyle modification, particularly medical nutrition therapy combined with regular physical activity, remains the cornerstone of GDM management and is effective in the majority of cases when implemented early and tailored to cultural and physiological needs. When lifestyle measures are insufficient, pharmacological therapies—primarily insulin and, in selected cases, metformin—provide effective glycemic control and significantly reduce the risk of adverse pregnancy outcomes such as macrosomia, preeclampsia, and neonatal complications. Emerging precision-based strategies that incorporate maternal characteristics, metabolic markers, and behavioral factors further enhance treatment effectiveness by enabling targeted and timely interventions. Despite strong evidence supporting current therapeutic approaches, challenges persist in sustaining postpartum adherence and preventing progression to type 2 diabetes mellitus. Therefore, integrated models combining lifestyle counseling, pharmacological management, digital monitoring, and long-term follow-up are essential. Overall, a comprehensive, patient-centered therapeutic framework is critical for improving both short-term pregnancy outcomes and long-term metabolic health in women affected by gestational diabetes mellitus.

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