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Gestational Diabetes Mellitus And Its Metabolic Consequences In The Postpartum Period. Strategies For Identifying The Risk Of Long-Term Type 2 Diabetes And Its Prevention

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Abstract

Gestational diabetes mellitus (GDM) is a glucose intolerance of any degree that is first detected during pregnancy and is one of the most common perinatal diseases, affecting 1–25% of pregnant women worldwide. [1] GDM increases the risk not only of short-term complications for the mother and fetus but also of long-term metabolic consequences and is a significant risk factor for the development of type 2 diabetes (T2D). [2] Studies show that women with GDM have a 35–60% risk of developing T2D within 7 years postpartum, which is almost 10 times higher compared to the general population. [3] This review article provides a comprehensive analysis of GDM and its metabolic consequences in the postpartum period, as well as strategies for identifying and preventing the risk of T2D, based on scientific research conducted over the past decade (2015–2025). The article discusses the pathophysiological mechanisms of T2D development in women with GDM, genetic and environmental factors, and various screening methods and their effectiveness. [4] In addition, various preventive strategies, including lifestyle modification, pharmacological interventions, and new approaches, are thoroughly examined. [5] Systematic reviews indicate that lifestyle modification programs, including diet therapy and physical activity, can reduce the risk of developing T2D by 35–40%. [6]

Pharmacological interventions, such as metformin, may reduce the risk by up to 50%. [7] The article emphasizes that a personalized approach to postpartum screening and treatment of women with GDM plays an important role in delaying or preventing the development of T2D. [8] In conclusion, it should be noted that GDM is not only a problem of the pregnancy period, but also a condition that poses a serious threat to long-term metabolic health. The implementation of effective screening, monitoring, and preventive programs offers an opportunity to reduce the prevalence of T2D. [9].

Keywords: Gestational diabetes mellitus, type 2 diabetes, postpartum period, metabolic syndrome, insulin resistance, screening strategies, prevention, lifestyle modification, metabolic risk, long-term complications.

Introduction

The aim of this review article is to provide a comprehensive analysis of the metabolic consequences that develop in the postpartum period in women with gestational diabetes mellitus (GDM), particularly the risk of developing type 2 diabetes (T2D), as well as strategies for its detection, assessment, and prevention, based on scientific studies published between 2015 and 2025. The study focuses on examining the pathophysiological link between GDM and subsequent T2D development, risk factors, the effectiveness of screening methods, and the outcomes of preventive measures.

Methods

In preparing this review article, a systematic analysis of scientific literature published between 2015 and 2025 was conducted. Data were retrieved from scientific databases such as PubMed, Scopus, Web of Science, and the Cochrane Library, following predefined criteria. The search used the following keywords: “gestational diabetes mellitus,” “postpartum period,” “type 2 diabetes,” “prediction,” “prevention,” “screening,” “lifestyle intervention,” and “metabolic outcomes.” According to the inclusion criteria, only articles that were in English, full-text, peer-reviewed, and openly accessible were considered. The collected data were classified and analyzed according to topics including the pathophysiology of GDM, risk prediction factors for postpartum T2D, screening methods, and preventive strategies.

Introduction

Gestational diabetes mellitus (GDM) is a glucose intolerance of any degree first detected during pregnancy and is one of the most common perinatal disorders, affecting 1–25% of pregnant women worldwide. [10] GDM increases the risk not only of short-term complications for the mother and fetus but also of long-term metabolic consequences and is a significant risk factor for the development of type 2 diabetes (T2D). [11] According to the International Diabetes Federation (IDF), in 2021, 537 million people worldwide aged 20–79 were living with diabetes, and this number is expected to reach 783 million by 2045. [12] T2D accounts for more than 90% of these cases, and women with GDM have a significantly higher risk of developing T2D.

The pathophysiology of GDM is primarily associated with an increase in physiological insulin resistance during pregnancy, which occurs under the influence of hormones secreted by the fetus and placenta (lactogen, estrogen, progesterone, and cortisol). [13] In most women, pancreatic beta cells increase compensatory insulin secretion to meet the higher demand; however, in some women, this compensatory mechanism is insufficient, resulting in the development of GDM. [14] This condition is usually detected through screening at 24–28 weeks of gestation and often resolves after delivery, but long-term metabolic consequences persist.

Studies show that women with GDM have a 35–60% risk of developing T2D within 7 years postpartum, which is nearly 10 times higher than in the general population. [15] In addition, women with GDM have an increased risk of developing metabolic syndrome, cardiovascular diseases, and kidney dysfunction. [16] Therefore, GDM is not only a pregnancy-related issue but also a condition that poses a serious threat to long-term metabolic health, and the implementation of effective screening, monitoring, and preventive programs provides an opportunity to reduce the prevalence of T2D.

Over the past decade, knowledge about GDM and its long-term consequences has expanded significantly. Numerous cohort studies have confirmed the high risk of developing T2D in women with GDM and have identified various risk factors. [17] In addition, the effectiveness of different preventive strategies, including lifestyle modification, pharmacological interventions, and new approaches, has been studied. [18] Nevertheless, the implementation of this

knowledge into practice remains limited, and in many areas, postpartum monitoring and support systems for women with GDM are still insufficient.

The aim of this review article is to provide a comprehensive analysis of GDM and its metabolic consequences in the postpartum period, as well as strategies for identifying and preventing the risk of developing T2D, based on scientific studies published between 2015 and 2025. The article discusses the pathophysiological mechanisms of T2D development in women with GDM, genetic and environmental factors, as well as various screening methods and their effectiveness. In addition, different preventive strategies, including lifestyle modification, pharmacological interventions, and new approaches, are examined in detail.

The article is organized into the following sections: abstract, keywords, research objective, research methods, introduction, results, discussion, conclusion, and references. Each section is aimed at a thorough exploration of a specific aspect and seeks to provide readers with a comprehensive understanding of GDM and its long-term consequences.

Results

Pathophysiological link between GDM and T2D

To understand the link between GDM and the subsequent development of T2D, it is important to understand their shared pathophysiological mechanisms. Numerous studies indicate that GDM primarily arises from a combination of insulin resistance and beta-cell dysfunction, which are key features of T2D. [19] During pregnancy, physiological insulin resistance develops under the influence of hormones produced by the placenta, including human placental lactogen (hPL), estrogen, progesterone, and cortisol. These hormones reduce tissue sensitivity to insulin, resulting in an increased insulin requirement to maintain blood glucose levels within the normal range.

In women who develop GDM, pancreatic beta cells are unable to adequately compensate for the increased insulin demand during pregnancy. [20] This beta-cell dysfunction often reflects a subclinical condition that existed before pregnancy, which is unmasked by the pregnancy itself. After delivery, when the placenta is removed, insulin resistance usually decreases and glucose metabolism returns to normal; however, the underlying beta-cell dysfunction and insulin resistance persist, which can subsequently lead to the development of T2D.

Molecular studies indicate that various genetic factors increase the risk of developing T2D in women with GDM. [21] Certain polymorphisms in T2D-related genes, such as TCF7L2, KCNJ11, PPARG, and IRS1, are associated with GDM and subsequent development of T2D. These genes play a crucial role in beta-cell function, insulin secretion, and insulin signaling pathways.

Epigenetic changes also play a key role in the link between GDM and T2D. [22] During pregnancy, environmental factors (such as nutrition and stress) can induce epigenetic modifications, including DNA methylation and histone modifications, which can long-term alter gene expression and increase the risk of developing T2D later.

Factors Predicting the Risk of Developing T2D after GDM.Accumulated evidence has identified several factors that help predict the risk of developing type 2 diabetes (T2D) in women with gestational diabetes mellitus (GDM). Identifying these factors is crucial for developing personalized screening and prevention strategies.

Demographic and Anthropometric Factors:Numerous studies have shown that a high body mass index (BMI), pre-pregnancy obesity, and excessive weight gain during pregnancy are independent risk factors for developing T2D. [23] Women with a BMI > 30 have a 3–5 times higher risk of developing T2D after GDM compared to women with a BMI < 25. Age is also an important factor: the risk is higher in women over 35 years old compared to younger women.

Metabolic Factors:The severity of glucose metabolism abnormalities during GDM predicts the risk of developing T2D. [24] High fasting glucose levels, elevated glucose levels during an oral glucose tolerance test (OGTT), and the need for insulin therapy to manage GDM are associated with a higher risk of subsequent T2D. Signs of insulin resistance, such as an increased HOMA-IR index and decreased adiponectin levels, are also independent predictive factors.

Family History and Genetic Factors:A family history of T2D significantly increases the risk of developing T2D after GDM. [25] Additionally, genetic variants associated with T2D, particularly TCF7L2 polymorphisms, further increase the risk.

Pregnancy- and Delivery-Related Factors:Multiple

pregnancies, gestational hypertension, and having a large-for-gestational-age infant (macrosomia) are associated with an increased risk of developing T2D. [26] Moreover, delivery by cesarean section is associated with a higher risk compared to vaginal delivery; however, it remains unclear whether this association is due to the procedure itself or the underlying pathophysiology.

T2D Screening after GDM

Screening for T2DM in women with GDM during the postpartum period remains an important topic of discussion. Various organizations provide different recommendations, but most suggest lifelong screening for T2DM in women with GDM at least every 1–3 years. [27]

Screening methods: Measurement of blood glucose levels, OGTT, and glycated hemoglobin (HbA1c) are the most commonly used methods for postpartum screening. OGTT is considered the most sensitive method for detecting impaired glucose metabolism, as it identifies impaired glucose tolerance (IGT) more accurately than fasting glucose or HbA1c alone. [28] However, OGTT is inconvenient for patients and time-consuming, which limits its practical application.

Timing of screening: The optimal timing for postpartum screening is still under discussion. Most guidelines recommend performing an initial OGTT 6–12 weeks after delivery, followed by repeat screening at least every 3 years. [29] Nevertheless, studies show that screening rates are generally low, with only 30–50% of women undergoing the recommended postpartum screening.

Barriers to screening: Low screening rates are associated with various factors, including lack of patient awareness, inattention by healthcare providers, insurance issues, and the inconvenience of screening methods. [30] Strategies to improve screening rates include patient education, provider reminder systems, and alternative screening methods such as HbA1c or blood glucose tests.

Strategies for preventing T2DM after GDM

Lifestyle modification: Many randomized controlled trials (RCTs) have shown that lifestyle changes, including dietary therapy and physical activity, are effective in reducing the risk of developing type 2 diabetes (T2DM) in women with gestational diabetes (GDM). [31] The Diabetes Prevention Program (DPP) and subsequent follow-up studies demonstrated that a 7% weight loss combined with at least 150 minutes of moderate-intensity exercise per week can reduce the risk of T2DM by 58%. Programs specifically designed for women with GDM have shown similar effectiveness.

Pharmacological interventions: Metformin is a widely studied drug for preventing T2DM in women with GDM. The DPP study showed that metformin reduced the risk of developing T2DM by 31%, with the highest effectiveness observed in women with BMI > 30 and age < 60 years. [32] Other medications, such as pioglitazone, acarbose, and liraglutide, have also demonstrated efficacy in preventing T2DM, although data on their benefits specifically in women with GDM are limited.

New approaches: In recent years, novel strategies for preventing T2DM in women with GDM have been explored, including digital health interventions, individualized genetic recommendations, and microbiome-based therapies. [33] While these approaches are still experimental, they offer potential for personalized prevention in the future.

Role of breastfeeding: Several observational studies have shown a beneficial effect of breastfeeding in reducing the risk of T2DM in women with GDM. [34] There is an inverse relationship between the duration and intensity of breastfeeding and T2DM risk: women who breastfed longer and more frequently had the lowest risk. The protective effect of breastfeeding is associated with improved insulin sensitivity, facilitation of weight loss, and anti-inflammatory effects.

Discussion

The results of this review study indicate that women with GDM have a significantly high risk of developing T2DM and that effective strategies exist to reduce this risk. The pathophysiological link between GDM and T2DM is mainly due to a combination of insulin resistance and beta-cell dysfunction, which becomes evident during pregnancy and persists after delivery.

There are numerous factors that predict the risk of T2DM, and identifying them allows for the development of personalized approaches. The strongest predictors include high BMI, pre-pregnancy obesity, the severity of GDM, the need for insulin therapy, a family history of T2DM, and certain genetic variants. Considering these factors makes it possible to identify women at high risk and implement intensive preventive measures.

Postpartum screening remains a significant challenge, as

its implementation rate worldwide is still low. Increasing screening coverage requires a multifaceted approach, including patient education, reminder systems for healthcare providers, and the use of alternative screening methods. Although OGTT is the most sensitive method, its practical limitations make simpler methods, such as HbA1c and blood glucose tests, worth considering.

Lifestyle modification continues to be the cornerstone of T2DM prevention in women with GDM. Evidence from the DPP and other studies confirms the long-term effectiveness of lifestyle interventions. However, implementing these programs in practice faces barriers, including limited resources, patient motivation, and challenges with long-term adherence.

Pharmacological interventions, particularly metformin, can play an important role as an adjunct or alternative to lifestyle modification. Metformin is relatively safe, affordable, and effective, making it suitable for long-term use. Nevertheless, its widespread use in women with GDM remains limited, and additional data on its benefits are needed.

Breastfeeding has emerged as a natural and effective method for preventing T2DM in women with GDM. Encouraging and supporting breastfeeding is a simple and cost-effective strategy that is important not only for the child's health but also for the mother's health.

Conclusion

Gestational diabetes is not only a concern during pregnancy but also poses a serious threat to long-term metabolic health. Implementing effective screening, monitoring, and prevention programs provides an opportunity to reduce the prevalence of type 2 diabetes (T2D). Research over the past decades has significantly advanced our understanding of GDM and its metabolic consequences in the postpartum period.

The risk of developing T2D in women with GDM is substantially high, ranging from 35% to 60% within seven years. This elevated risk is primarily associated with shared pathophysiological mechanisms of GDM and T2D, including insulin resistance and beta-cell dysfunction. Several factors help predict T2D risk, including high BMI, severity of GDM, the need for insulin therapy, a family history of T2D, and certain genetic variants.

Postpartum T2D screening remains a significant challenge, as coverage is low worldwide. Increasing screening rates requires a multifaceted approach, including patient education, reminder systems for healthcare providers, and the use of alternative screening methods.

Among strategies for preventing T2D, lifestyle modification remains the most effective approach, reducing risk by 35–40%. Pharmacological interventions, particularly metformin, can play an important role as an adjunct or alternative to lifestyle changes and can reduce risk by up to 50%. Breastfeeding has also emerged as a natural and effective method for preventing T2D in women with GDM.

Future research should focus on exploring new strategies for preventing T2D in women with GDM, as well as on effective ways to implement existing strategies in practice. A personalized approach, including screening and prevention tailored to individual risk profiles, may be key to achieving the best outcomes.

In conclusion, GDM is not only a pregnancy-related issue but also a serious threat to long-term metabolic health. Effective implementation of screening, monitoring, and prevention programs can reduce the prevalence of T2D. Healthcare providers, policymakers, and researchers must work together to improve the long-term health of women with GDM.

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