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**ASSOCIATION BETWEEN CONTINUOUS GLUCOSE MONITORING
PARAMETERS AND FETAL HEMODYNAMICS IN PREGNANCIES
COMPLICATED BY DIABETES MELLITUS**

Bakhtiyorova Madina Bakhtiyor kizi,

Yusupbaev Rustem Bazarbaevich

*Republican Specialized Scientific and Practical Medical Center for Maternal and
Child Health, Tashkent, Uzbekistan*

ABSTRACT

Relevance. Pregnancies complicated by type 1 diabetes mellitus (T1DM), type 2 diabetes mellitus (T2DM), and gestational diabetes mellitus (GDM) are associated with an increased risk of adverse maternal and perinatal outcomes. Conventional assessment of glycemic control based on intermittent blood glucose measurements and glycated hemoglobin (HbA1c) may not fully reflect daily glucose fluctuations, postprandial hyperglycemia, nocturnal glucose abnormalities, and glycemic variability. Continuous glucose monitoring (CGM) provides detailed information on maternal glycemic patterns, including time in range (TIR), time above range (TAR), time below range (TBR), mean glucose, and coefficient of variation (CV). At the same time, fetal Doppler assessment allows non-invasive evaluation of fetoplacental and fetal circulation. The relationship between CGM-derived maternal glycemic patterns and fetal Doppler parameters in pregnancies complicated by different types of diabetes remains insufficiently investigated.

Objective. To evaluate the association between maternal CGM-derived glycemic parameters and fetal and fetoplacental Doppler indices in pregnancies complicated by T1DM, T2DM, and GDM, and to assess their potential value in predicting adverse perinatal outcomes.

Materials and Methods. A prospective observational study is planned to include pregnant women with T1DM, T2DM, and GDM, as well as a control group

of pregnant women without diabetes. Maternal glycemic status will be assessed using 14-day continuous glucose monitoring. The main CGM parameters will include mean glucose concentration, TIR, TAR, TBR, standard deviation, and CV. Fetal and fetoplacental circulation will be assessed by Doppler ultrasonography, including the umbilical artery (UA), middle cerebral artery (MCA), cerebroplacental ratio (CPR), and ductus venosus (DV). Associations between CGM-derived glycemic parameters and Doppler indices will be analyzed. Pregnancy and neonatal outcomes, including fetal growth abnormalities, preterm birth, birth weight, neonatal hypoglycemia, Apgar scores, and admission to the neonatal intensive care unit, will also be evaluated.

Expected Results. Increased maternal hyperglycemic exposure and glycemic variability are expected to be associated with alterations in fetal and fetoplacental hemodynamic parameters. Reduced TIR and increased TAR and CV may be associated with changes in MCA, UA, CPR, and potentially DV indices. The combined assessment of CGM and Doppler parameters may provide additional information for identifying pregnancies at increased risk of adverse perinatal outcomes compared with conventional glycemic assessment alone.

Conclusion. Combined assessment of maternal glycemic patterns using CGM and fetal hemodynamics using Doppler ultrasonography represents a promising approach to studying the relationship between maternal glucose fluctuations, fetal circulatory adaptation, and perinatal outcomes in pregnancies complicated by diabetes mellitus. Identification of specific CGM patterns associated with fetal hemodynamic changes may contribute to improved risk stratification and individualized monitoring of high-risk pregnancies.

Keywords: pregnancy, type 1 diabetes mellitus, type 2 diabetes mellitus, gestational diabetes mellitus, continuous glucose monitoring, CGM, glycemic variability, time in range, Doppler ultrasonography, middle cerebral artery, cerebroplacental ratio, ductus venosus, perinatal outcomes.

INTRODUCTION

Pregnancies complicated by diabetes mellitus remain an important clinical

problem due to the increased risk of maternal, fetal, and neonatal complications. Pregestational T1DM and T2DM, as well as GDM, are associated with an increased risk of hypertensive disorders of pregnancy, abnormal fetal growth, preterm delivery, neonatal hypoglycemia, and admission to neonatal intensive care.

Adequate maternal glycemic control is one of the major determinants of favorable pregnancy outcomes. However, conventional methods of glycemic assessment have important limitations. Capillary blood glucose measurements provide information only at specific time points and may fail to identify prolonged or transient episodes of hyperglycemia and hypoglycemia, particularly during nighttime and postprandial periods. HbA1c reflects average glycemic exposure over a longer period but does not characterize short-term glucose fluctuations or glycemic variability.

Continuous glucose monitoring provides a more detailed assessment of the maternal glycemic profile. CGM-derived parameters include time in the target glucose range (TIR), time above the target range (TAR), time below the target range (TBR), mean glucose concentration, standard deviation, and coefficient of variation. In pregnancy, the recommended CGM target range is generally defined as 3.5–7.8 mmol/L (63–140 mg/dL). These parameters make it possible to quantify both overall glycemic exposure and the magnitude of glucose fluctuations.

Maternal hyperglycemia may influence placental function, fetal metabolism, fetal growth, and fetal oxygen requirements. Therefore, alterations in maternal glycemia may potentially be accompanied by adaptive changes in fetal and fetoplacental circulation.

Doppler ultrasonography provides a non-invasive method for assessing these hemodynamic changes. Umbilical artery Doppler reflects placental vascular resistance, whereas the fetal middle cerebral artery provides information on cerebral circulation. The cerebroplacental ratio, calculated using MCA and UA indices, provides an integrated assessment of the relationship between fetal cerebral and placental circulation. Ductus venosus Doppler may provide additional information regarding fetal cardiovascular adaptation, particularly in compromised

fetal conditions.

Although CGM parameters and fetal Doppler indices have independently been investigated in pregnancies complicated by diabetes, the relationship between short-term maternal glucose dynamics and fetal hemodynamic changes remains insufficiently characterized. In particular, there is limited evidence regarding whether CGM-derived hyperglycemic exposure and glycemic variability are associated with changes in MCA, CPR, and DV Doppler parameters and whether their combined assessment may improve prediction of adverse perinatal outcomes.

The study of the relationship between maternal glycemic phenotype, fetal hemodynamic phenotype, and perinatal outcome may therefore represent a promising direction for improving risk assessment in pregnancies complicated by diabetes mellitus.

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OBJECTIVE

To investigate the relationship between CGM-derived maternal glycemic parameters and fetal and fetoplacental Doppler indices in pregnant women with T1DM, T2DM, and GDM and to determine their potential role in predicting adverse perinatal outcomes.

MATERIALS AND METHODS

Maternal glucose levels will be monitored using a continuous glucose monitoring system for a 14-day period. CGM data will be analyzed to determine mean glucose concentration, TIR, TAR, TBR, standard deviation, and coefficient of variation. Particular attention will be paid to the duration and frequency of hyperglycemic episodes and the overall glycemic variability. The pregnancy-specific glucose target range of 3.5–7.8 mmol/L will be used for the assessment of TIR.

Fetal ultrasonography with Doppler assessment will be performed during the CGM observation period. Doppler examination will include assessment of the umbilical artery, fetal middle cerebral artery, cerebroplacental ratio, and ductus venosus.

Where technically and clinically feasible, Doppler assessment may be performed at the beginning and at the end of the 14-day CGM period. This approach will allow evaluation not only of cross-sectional associations between glycemia and fetal circulation but also of potential changes in fetal hemodynamic parameters during the monitoring period.

EXPECTED RESULTS AND DISCUSSION

The proposed study is expected to provide a detailed characterization of maternal glycemic patterns in pregnancies complicated by different types of diabetes and to determine whether these patterns are associated with measurable changes in fetal and fetoplacental circulation.

A particularly important aspect of the study will be the assessment of glycemic variability. Two pregnant women may have similar HbA1c values while having substantially different daily glucose profiles. One patient may maintain relatively stable glucose concentrations, whereas another may experience repeated fluctuations between hypo- and hyperglycemia. CGM allows these differences to be quantified and may therefore provide information that cannot be obtained from HbA1c alone.

The study will evaluate whether increased TAR and glycemic variability or

decreased TIR are associated with altered MCA pulsatility, placental vascular resistance, changes in CPR, or abnormalities in DV blood flow.

Another important aspect will be the temporal relationship between maternal glucose exposure and fetal hemodynamics. Comparison of Doppler parameters with glucose patterns during the preceding hours, days, and the complete 14-day CGM period may help determine whether fetal circulatory changes are associated predominantly with chronic glycemic exposure or may also be influenced by short-term maternal glucose fluctuations.

The inclusion of women with T1DM, T2DM, and GDM will allow assessment of whether the association between maternal glycemic patterns and fetal hemodynamics differs according to diabetes type. The study may also evaluate the incremental predictive value of combining clinical, CGM, and Doppler data. A clinical model based on conventional maternal risk factors and HbA1c may be compared with a model additionally incorporating CGM parameters and subsequently with a combined model including both CGM and fetal Doppler indices.

Such an approach may help determine whether the combination of maternal glycemic exposure and fetal hemodynamic assessment provides additional information for identifying pregnancies at increased risk of adverse perinatal outcomes.

CONCLUSION

Continuous glucose monitoring provides detailed information on maternal glycemic exposure and variability that cannot be fully obtained using intermittent glucose measurements or HbA1c alone. Doppler ultrasonography, in turn, provides functional information regarding placental resistance and fetal circulatory adaptation.

The combined assessment of CGM-derived glycemic parameters and fetal Doppler indices may therefore provide a more comprehensive understanding of the relationship between maternal diabetes and fetal condition.

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