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Association between Gestational Diabetes Mellitus and Pregnancy Outcomes

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ABSTRACT

Background & objective: Pregnancy induces physiological lipid changes, which are amplified in the setting of hyperglycemia. Gestational diabetes mellitus (GDM) is associated with dyslipidemia that may contribute to adverse fetomaternal outcomes. This study compared the fetomaternal outcomes between pregnant women with GDM in their third-trimester and those in women with normal pregnancy in order to determine the association between GDM and pregnancy outcomes.

Methods: In this prospective observational study, 182 pregnant women in the third trimester were enrolled, comprising 112 cases with GDM and 70 controls without GDM, at Bangladesh Medical University, Dhaka. Fasting lipid panels were obtained in the third trimester and were analyzed. Dyslipidemia was defined using conventional criteria TC ≥ 200 mg/dL, LDL-C ≥ 130 mg/dL, TG ≥ 150 mg/dL, HDL-C < 50 mg/dL and a composite TG: HDL-C ratio > 3.5. Participants were followed for maternal and perinatal outcomes, including PIH/preeclampsia, preterm birth, Apgar scores, NICU admission, and birth weight.

Results: Compared with controls, the GDM group exhibited higher serum TC and TG, and a higher TG: HDL-C ratio in the third trimester (p-values for TC = 0.008, TG = 0.013, TG: HDL-C ratio = 0.025). The prevalence of dyslipidemia TC ≥ 200 mg/dL, TG ≥ 150 mg/dL, or LDL-C ≥ 130 mg/dL was greater among cases, p = 0.002, 0.009, and 0.002, respectively, with TG: HDL-C > 3.5 significantly more frequent in the GDM group (p = 0.004). Maternal outcomes showed higher incidence of PIH (14.3% vs. 0% and preeclampsia 12.5% vs. 1.4%) in cases (p = 0.001 and p = 0.008). Perinatal outcomes revealed higher rates of low-birth-weight (LBW) and preterm birth in the GDM group (p = 0.001 and p = 0.005). Apgar scores < 7 at birth were more common among cases (p = 0.033). Although Neonatal Intensive Care Unit (NICU) admission, SGA, and LGA did not differ significantly, a trend toward adverse neonatal outcomes was observed in GDM pregnancies with dyslipidemia.

Conclusion: Third-trimester dyslipidemia, particularly elevated TG and TG: HDL-C ratio, is more prevalent in pregnancies affected by GDM and is associated with increased maternal hypertensive disorders and adverse perinatal outcomes. The TG: HDL-C ratio emerges as a potential surrogate marker of dyslipidemia-related risk beyond glycemic assessment. Integrating lipid profiling into GDM management could enhance risk stratification and guide targeted obstetric surveillance and postpartum cardiovascular risk mitigation.

Keywords: Gestational diabetes mellitus, hyperglycemia in pregnancy, fetomaternal outcomes etc.

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INTRODUCTION

Pregnancy is a period of dynamic metabolic adaptation, specifically designed to prioritize the energetic and nutritional requirements of the developing fetus. A central feature of this adaptation is the development of physiological hyperlipidemia, characterized by a progressive rise in serum triglycerides (TG), increased adipose tissue accumulation, & enhanced hepatic lipid production.[1,2] Throughout a healthy gestation, most lipid fractions rise steadily, often reaching twice their pre-pregnancy level, while high-density lipoprotein cholesterol (HDL-C) levels typically plateau or experience a slight decline toward the third trimester.[3,4] This shift is essential for ensuring a constant supply of fatty acids for fetal organogenesis and membrane synthesis.[5]

However, in the presence of gestational diabetes mellitus (GDM), these adaptations often exceed physiological limits and become pathological. GDM defined as glucose intolerance with its first recognition during pregnancy is frequently accompanied by a distinct and aggressive dyslipidemic profile. While total cholesterol (TC) and LDL-C may not significantly differ between diabetic & normoglycemic pregnancies, the GDM environment is characterized by significantly higher TG levels, elevated TG/HDL-C ratios, and lower HDL-C concentrations.[6] This "lipid triad" is a metabolic hallmark of the insulin-resistant state and is increasingly viewed as a primary driver of pregnancy complications.

The clinical significance of this dyslipidemia lies in its strong association with adverse pregnancy outcomes. Maternal lipid abnormalities are no longer considered mere side effects of hyperglycemia but are recognized as active contributors to maternal and fetal morbidity.[7] Elevated triglycerides in early and late pregnancy have been linked to a higher incidence of preeclampsia, pregnancy-induced hypertension (PIH), & preterm birth.[8,10] Furthermore, the impact on the fetus is profound, with maternal dyslipidemia serving as a significant predictor for large-for-gestational-age (LGA) infants, macrosomia, and intrahepatic cholestasis.[11,12]

Despite these known risks, the management of dyslipidemia during pregnancy remains a significant challenge because conventional lipid-lowering therapies (such as statins) are contraindicated due to potential teratogenicity.[13,14] This highlights a critical need to understand how GDM with consequent lipid disturbances interact to influence birth outcomes. The present study, therefore, seeks to explore the specific associations between these metabolic markers and the resulting fetomaternal outcomes, aiming to identify potential windows for intervention that extend beyond standard glucose monitoring.

METHODS

This prospective observational study was conducted at the Departments of Obstetrics and Gynaecology, Fetomaternal Medicine & Endocrinology, Bangladesh Medical University (BMU) Hospital, Dhaka, between September 2022 to August 2025. A total of 182 pregnant women in their third trimester were enrolled, comprising 112 cases with gestational diabetes mellitus (GDM) and 70 controls without GDM. Pregnant women aged 20 - 35 years diagnosed with GDM were included as case and those without GDM as control. Hyperglycemia that falls below the thresholds for overt diabetes, first recognized during pregnancy was defined as GDM. The IADPSG/WHO criteria recommend a one-step 75-gram OGTT between 24 and 28 weeks of gestation. Accordingly, GDM was diagnosed if one or more of the following plasma glucose thresholds were met or exceeded: Fasting plasma glucose (FPG): ≥ 92 mg/dL (5.1 mmol/L), or 1-hour post 75g glucose load: ≥ 180 mg/dL (10.0 mmol/L), or 2-hour post 75g glucose load: ≥ 153 mg/dL (8.5 mmol/L). However, pregnant women who received treatment for dyslipidaemia, steroid therapy or had multiple gestation, or had smoking or alcohol abuse, or presented with other known pregnancy complications, medical or surgical diseases (i.e. hypertensive disorder, liver and kidney diseases) were exclude from the study.

Fasting lipid panels of each participant were analyzed. Dyslipidaemia was determined based on the guidelines set by the National Cholesterol Education Program-Adult Treatment Panel (NCEP-ATP III) if serum total cholesterol was ≥ 200 mg/dl or HDL-cholesterol <50 mg/dl or LDL-cholesterol ≥ 130 mg/dl or triglycerides ≥ 150 mg/dl (NCEP, 2001). However, in the present study dyslipidaemia was more precisely defined if Tg:HDL ratio exceeded 3.5, for a TG/HDL ratio > 3.5 has an atherogenic potential to be associated with increased adverse cardiovascular events.[15] Participants were followed for maternal and perinatal outcomes, including PIH/preeclampsia, preterm birth, Apgar scores, NICU admission, and birth weight.

Collected data were processed and analyzed using SPSS (Statistical Package for Social Sciences) software. Descriptive statistics were used to summarize the data. While Chi-square (χ^2) test was used to compare data presented on a categorical scale between the case and control groups, Unpaired T-test was used to compare data presented on a continuous scale between groups. The level of statistical significance was set at 5%, and a p-value of < 0.05 was considered statistically significant.

RESULTS

The age distribution showed that approximately 40% of the cases and 37% of the controls were between 25 and 30 years old. There was no statistically significant difference in age between the case and control groups (p = 0.776). The prevalence of overweight and obesity was significantly higher in the case group (65.2%) compared to the control group (24.3%) (p < 0.001). Study of obstetric characteristics revealed that multiparity was significantly higher in the case group (50%) compared to the control group (18.6%) (p < 0.001). However, the difference in gravidity between the groups was not significant (p = 0.489). The mean gestational age at delivery was significantly lower in the case group than in the control group (p = 0.015). A family history of diabetes mellitus was also significantly higher in the case group (p = 0.035) (Table I).

Serum total cholesterol (TC) and triglycerides (TG) were significantly higher in the case group compared to the control group (p = 0.008 and p = 0.013, respectively). Correspondingly, the TG:HDL−C ratio was also significantly higher in the case group (p=0.025) (Table II). The prevalence of hypercholesterolemia (TC > 200 mg/dL) and hypertriglyceridemia (TG > 150 mg/dL) was significantly higher in the case group compared to the control group (p = 0.002 and p = 0.009, respectively). A raised LDL cholesterol (≥ 130 mg/dL) was also significantly associated with the case group (p = 0.002). While the prevalence of reduced HDL-C (< 50 mg/dL) was higher in the case group, the difference was not statistically significant (p = 0.127). Overall, the presence of dyslipidemia (TG:HDL-C > 3.5) was overwhelmingly higher in the case group (p = 0.004) (Table II & Table III).

Pregnancy-Induced Hypertension (PIH) developed in 16(14.3%) patients of the case group, as opposed to none in the control group (p = 0.001). The incidence of preeclampsia was notably higher in the case group (12.5%) compared to the control group (1.4%) (p=0.008) (Table IV).

Perinatal outcomes could not be recorded for two patients in the case group and 23 patients in the control group as they did not deliver at the study hospital. The incidence of LBW neonates and preterm birth was significantly higher in the case group compared to the control group (p = 0.001 and p = 0.005, respectively). While an APGAR score of < 7 at birth was significantly higher in the case group (p = 0.033), only three cases of asphyxia (APGAR < 7) persisted at five minutes of birth (p = 0.625). Although the incidence of NICU admission and small for gestational age (SGA) was higher in the cases, the differences were not statistically significant (p = 0.191 and p = 0.296, respectively). The incidence of macrosomia or large for gestational age (LGA) did not differ significantly between the groups (p = 0.897) (Table V).

Table I: Distribution of baseline characteristics between case and control groups

Baseline Characteristics	Group		p-value
	Case (n = 112)	Control (n = 70)	
Age (years)			
< 25	27(24.1)	18(25.8)	
25 – 30	44(39.3)	26(37.1)	
≥ 30	41(36.6)	26(37.1)	
Mean ± SD	27.9 ± 4.9	27.7 ± 4.6	0.776
BMI (kg/m²)			
<18.5 (Underweight)	1(0.9)	1(1.4)	
18.5 – 24.9 (Normal)	39(34.9)	52(74.3)	
25 – 29.9 (Overweight)	49(43.8)	15(21.4)	< 0.001*
Obese (≥ 30)	23(21.4)	2(2.9)	
Parity			
Primipara	56(50.0)	57(81.4)	< 0.001*
Multipara	56(50.0)	13(18.6)	
Gravida			
Primigravida	36(32.1)	26(37.1)	0.489*
Multigravida	76(67.9)	44(62.9)	
Gestational age at delivery (weeks)	36.9 ± 2.7	37.8 ± 2.3	0.015#
Family history of DM	51(45.5)	21(30.0)	0.035*

Figures in the parentheses indicate corresponding %; #Data were analyze using **Unpaired t-Test** and were presented as **mean ± SD**.

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Table II: Comparison lipid profile between case and control groups

Lipid Profiles (mg/dl)	Group		p-value
	Case (n = 112)	Control (n = 70)	
Serum TC	214.6 ± 43.9	197.3 ± 39.8	0.008
Serum LDL-C	118.6 ± 38.4	112.3 ± 30.6	0.246
Serum HDL-C	53.9 ± 11.7	56.9 ± 12.3	0.098
Serum Triglycerides	276.9 ± 110.9	235.6 ± 102.2	0.013
TG:HDL Ratio	5.3 ± 2.4	4.4 ± 2.9	0.025

Figures in the parentheses indicate corresponding %; #Data were analyze using **Unpaired t-Test** and were presented as **mean ± SD**.

Table III: Comparison lipid profile between case and control groups

Lipid Profiles (mg/dl)	Group		p-value
	Case (n = 112)	Control (n = 70)	
Raised TC (Serum TC ≥ 200 mg)	66(58.9)	25(35.7)	0.002
Raised LDL-C (serum LDL ≥ 130 mg)	42(37.5)	11(15.7)	0.002
Reduced HDL-C (Serum HDL < 50 mg)	41(36.6)	18(25.7)	0.127
Elevated Tg (Serum TG ≥ 150 mg)	103(92.0)	55(78.6)	0.009
Dyslipidaemia (TG:HDL ratio > 3.5)	89(79.5)	42(60.0)	0.004

Figures in the parentheses indicate corresponding %.
***Chi-squared Test** (χ^2) was done to analyze the data.

Table IV: Comparison maternal outcome between case and control groups

Maternal outcome	Group		p-value
	Case (n = 112)	Control (n = 70)	
PIH	16(14.3)	0(0.0)	0.001*
Preeclampsia	14(12.5)	1(1.4)	0.008*

Figures in the parentheses indicate corresponding %.
***Chi-squared Test** (χ^2) was done to analyze the data.

Table V: Comparison of neonatal outcome between case and control groups

Perinatal outcome	Group		p-value
	Case (n = 112)	Control (n = 70)	
Low Birth Weight (< 2.5 kg)	28(25.0)	4(8.5)	0.001*
APGAR1 < 7	10(9.1)	1(2.1)	0.033*
APGAR5 < 7	3(2.7)	0(0.0)	0.625**
NICU admission needed	15(13.6)	3(6.4)	0.191*
PTB (Preterm birth)	32(29.1)	4(8.5)	0.005*
SGA (Small for gestational age)	10(9.1)	2(4.3)	0.296*
Macrosomia / LGA	2(1.8)	1(2.1)	0.897**

Figures in the parentheses indicate corresponding %); ***Chi-squared Test** (χ^2) was done to analyze the data. ****Fisher's Exact Test** was done to analyze the data.

DISCUSSION

This study sought to elucidate the relationship between third-trimester lipid profiles and fetomaternal outcomes in pregnancies complicated by GDM. Our findings reveal that dyslipidemia-specifically an elevated TG:HDL-C ratio-is significantly more pronounced in women with GDM and is associated with a higher burden of adverse maternal and neonatal outcomes.

The study demonstrated that women with GDM exhibited significantly higher total cholesterol (TC) and triglycerides (TG) compared to normoglycemic controls. While HDL-C levels did not differ significantly, the prevalence of hypercholesterolemia (≥ 200 mg/dL) and elevated LDL-C (≥ 130 mg/dL) was markedly higher in the GDM group. Notably, a TG:HDL-C ratio > 3.5 was a frequent marker of dyslipidemia in these cases. Regarding clinical outcomes, PIH and preeclampsia were substantially more prevalent in the GDM cohort (PIH: 14.3% vs. 0%; preeclampsia: 12.5% vs. 1.4%). Neonatal outcome data showed higher rates of LBW, preterm birth, and 1-minute birth asphyxia in the GDM group, suggesting a complex metabolic impact on the fetus.

Normal pregnancy involves a physiological rise in TG and TC.[1] However, GDM amplifies this into a pathological state driven by insulin resistance. This interplay may hasten the development of atherogenic dense LDL particles.[1] The TG:HDL-C ratio serves as a surrogate marker for this atherogenic milieu.[15] In our study, this elevated ratio suggests a lipoprotein environment that promotes endothelial dysfunction and vascular inflammation, pathways directly implicated in placental pathology and hypertensive disorders.

Our results confirm a strong link between hyperlipidemia and PIH/preeclampsia in GDM patients. Multiple studies underscore the link between hyperlipidemia and preeclampsia in women with GDM, particularly elevated TG levels showed an increased risk of pre-eclampsia.[16] Women with TG in the upper quartile face a significantly higher risk of preeclampsia.[17,18] Additionally, meta-analyses show that hypertriglyceridemia often precedes the onset of preeclampsia.[19] & persists across all trimesters.[20]

Elevated TG-rich particles increase oxidative stress, potentially impairing nutrient transfer and contributing to both maternal hypertension and fetal growth restriction.[16]

It remains debated whether dyslipidemia is a cause or consequence of GDM. However, evidence suggests lipid alterations often emerge before a GDM diagnosis. For example, TG levels > 1.58 mmol/L as early as 11 weeks tend to be associated with GDM risk, independent of BMI.[21] The UPBEAT study[22] and subsequent meta-analyses[23] confirm that lipid changes manifest at least ten weeks prior to glycemic diagnosis and remain elevated throughout pregnancy.

Our findings of increased preterm birth align with evidence that maternal dyslipidemia elevates this risk,[11,24,25] particularly when present in the second trimester.[26,27] Dyslipidemia contributes to placental dysfunction and inflammation, which triggers early labor.[28]

While our study noted higher LBW rates, literature often links high maternal TG to fetal overgrowth. High maternal TG is consistently linked to heavier infants and LGA risk.[29-31] A meta-analysis of over 31,000 pregnancies confirmed that high TG and low HDL are key drivers of fetal macrosomia.[32] Conversely, SGA outcomes are often tied to abnormal placental development.[33] SGA has been linked to both high TG (via preeclampsia) and abnormally low lipid levels stemming from malnutrition or failed physiological expansion.[34,35]

The findings of the study could have several probable clinical implications:

- **Risk Stratification:** In pregnancies with GDM early identification of elevated TG and TG:HDL-C ratios can pinpoint women at high risk for preeclampsia and neonatal complications.

- **Therapeutic Interventions:** Given the safety concerns surrounding lipid-lowering therapies in pregnancy, emphasis should be on lifestyle interventions (dietary modification, physical activity as appropriate) to modulate lipid levels. Postpartum lipid management may have implications for long-term maternal cardiovascular risk.[36]

- **Monitoring:** Integrating lipid profiling into standard GDM care can guide closer fetal surveillance and more tailored obstetric planning.

Before drawing conclusion, it would be worth discussing the strengths and limitations of the study that may help us adopt conservative steps in generalizing the findings of the study to reference population.

Strengths:

Specifically targeted third-trimester lipids is directly relevant to birth outcomes. The use of the TG:HDL-C ratio > 3.5 provided a superior surrogate for measuring atherogenic risk in pregnancy.

Limitations:

- The study conducted in a single-center limits its generalizability to diverse genetic or demographic contexts.
- While the total sample (n = 182) allows detection of group differences in several lipid parameters and outcomes, some secondary outcomes (SGA/LGA) may have been underpowered to reach statistical significance.
- Additionally, the study relies on a single lipid measurement in the third trimester.
- A longitudinal approach across all trimesters would more accurately capture lipid trajectories.

CONCLUSION

The study confirms that third-trimester dyslipidemia is significantly more prevalent in women with GDM than in normoglycemic pregnancies. Specifically, triglyceride (TG) levels and the TG:HDL-C ratio were markedly elevated, indicating a more pathological metabolic environment in the GDM cohort.

Clinically, these lipid perturbations were associated with a higher burden of PIH and preeclampsia. While certain neonatal outcomes like NICU admission and growth abnormalities (SGA/LGA) did not reach statistical significance, the observed trends suggest that maternal dyslipidemia negatively influences fetal growth and neonatal adaptation.

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These findings underscore that dyslipidemia is a critical co-factor in GDM-related morbidity, rather than a mere byproduct of hyperglycemia. Integrating lipid profiling into standard GDM management could significantly improve risk stratification and enable more personalized obstetric care by addressing the underlying insulin resistance that persists beyond glycemic control.

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