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LIPID PROFILE AND CLINICAL CHARACTERISTICS OF WOMEN WITH GESTATIONAL DIABETES MELLITUS AND PREECLAMPSIA

LIPIDSKI PROFIL I KLINIČKE KARAKTERISTIKE ŽENA SA GESTACIONIM DIJABETES MELITUSOM I PREEKLAMPSIJOM

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Summary: Gestational diabetes mellitus (GDM) is associated with increased risk of pregnancy-induced hypertension and other maternal and foetal complications of pregnancy. The aims of the study were to evaluate the serum lipid profile of women with GDM, and determine the number of women with GDM who have preeclampsia (PE). A retrospective study of 84 women with GDM and 90 pregnant women with normal glucose tolerance (controls) was conducted. Women with GDM had significantly higher parity (p=0.047), total cholesterol (p=0.039) and triglycerides (p=0.033), but non-significantly lower HDL-cholesterol (p=0.086) when compared to controls. Systolic blood pressure was significantly elevated in women with GDM coupled with PE (GDM-PE; p=0.015), the mean birth weight of infants born to women with GDM-PE was significantly lower than that of women with only GDM (p=0.025). Women with GDM-PE had significantly higher triglycerides (p=0.020), had to be more multi-gravida (p=0.047) with significantly elevated VLDL-cholesterol (p=0.037) when compared with women with only GDM. 11.9% of women with GDM had PE. On the basis of these findings, it can be concluded that GDM is associated with hyperlipidaemia as evident by the significantly elevated total cholesterol and triglyceride concentrations. Women with dyslipidaemia and GDM are at risk of developing preeclampsia. It is imperative that blood lipids be evaluated in women with GDM during antenatal care as it would be helpful in the early detection and treatment of PE.

Keywords: gestational diabetes mellitus, preeclampsia, glucose, lipids, prevalence

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Kratak sadržaj: Gestacioni dijabetes melitus (GDM) povezan je sa povećanim rizikom od hipertenzije izazvane trudnoćom i drugih komplikacija trudnoće kod majke i fetusa. Ciljevi studije bili su da se odredi lipidski profil žena sa GDM, i utvrdi broj žena sa GDM koje imaju PE. Sprovedena je retrospektivna studija 84 žene sa GDM i 90 trudnica sa normalnom tolerancijom glukoze (kontrola). Žene sa GDM imale su značajno povišen paritet (p=0,047), ukupni holesterol (p=0,039) i trigliceride (p=0,033), ali i neznačajno niži HDL-holesterol (p=0,086) u poređenju sa kontrolom. Sistolni krvni pritisak bio je značajno povišen kod žena sa GDM u kombinaciji sa PE (GDM-PE; p=0,015), a prosečna težina novorođenčadi koju su rodile žene sa GDM-PE bila je značajno niža nego kod žena sa GDM (p=0,025). Žene sa GDM-PE imale su značajno povišene trigliceride (p=0,020), i sklonije su većem broju trudnoća (p=0,047) uz značajno povišen VLDL-holesterol (p=0,037), u poređenju sa ženama samo sa GDM. 11,9% žena sa GDM imalo je PE. Na osnovu tih nalaza može se zaključiti da je GDM povezan sa hiperlipidemijom, što se vidi iz značajno povišenih ukupnih koncentracija holesterola i triglicerida. Kod žena sa dislipidemijom i GDM postoji rizik od razvoja preeklampsije. Veoma je važno određivati lipide u krvi žena sa GDM u okviru prenatalne zaštite jer to pomaže ranom otkrivanju i lečenju PE.

Ključne reči: gestacioni dijabetes melitus, preeklampsija, glukoza, lipidi, prevalenca

Introduction

Pregnancy is commonly recognized as a state of physiological and temporary insulin resistance. This condition is driven by high concentrations of steroid hormones such as progesterone, estrogens, prolactin, cortisol and placenta-derived human placental lactogen. All of these are diabetogenic and combined cause decreased sensitivity of insulin receptors within target tissues (1). Gestational diabetes mellitus (GDM) is defined as carbohydrate intolerance of varying degrees of severity with onset or first recognition during pregnancy (2).

Gestational diabetes mellitus is the most common medical and metabolic complication of pregnancy, occurring in 1–14% of patients depending on the population described and the criteria used for diagnosis (3). It is a heterogeneous disorder in which age, obesity, and genetic background contribute to the severity of the disease. Women with GDM are at risk for later development of type 2 diabetes. Coustan and colleagues studied women who had previous gestational diabetes and found diabetes or impaired glucose tolerance (IGT) in 6% of those tested at 0–2 years, 13% for those tested at 3–4 years, 15% at 5–6 years, and 30% at 7–10 years postpartum (4). Other studies have documented type 2 diabetes at 3–5 years postpartum in 30–50% of women who had a pregnancy complicated by GDM (5, 6).

Gestational diabetes mellitus is accompanied by alterations in fasting, postprandial, and integrated 24h plasma concentrations of amino acids, glucose, and lipids. These changes include a 3-fold increase in plasma triglyceride concentration during the third trimester of pregnancy, elevation of plasma fatty acids, delayed postprandial clearance of fatty acids, and elevation of branched-chain amino acids (7). Clark and colleagues reported that women with GDM have higher triglycerides, free fatty acids and beta-hydroxybutyrate and lower high density lipoprotein (HDL) cholesterol than normal pregnant subjects (8). Therefore, women with prior GDM are at greater risk for developing hypertension, hyperlipidaemia and electrocardiogram abnormalities (9).

Maternal morbidity due to GDM may be immediate or long-term. Studies documented an increase in preeclampsia (PE), polyhydramnios, and operative delivery in pregnancies complicated by GDM (10, 11). The Toronto Tri-Hospital Gestational Diabetes Project, a prospective cohort study evaluating maternal and foetal outcomes with increasing carbohydrate intolerance, observed a significant association between glucose intolerance and an increased incidence of caesarean delivery, PE, and length of maternal hospitalization (11).

The abnormalities of carbohydrate metabolism observed in GDM may lead to other abnormalities such as those observed in insulin resistance, especially lipid abnormalities. Women with pregestational and GDM have been reported to have increased risk of PE (10–50 and 10–30%, respectively) and insulin resistance when compared with women with normal glucose tolerance whose rate of preeclampsia is 5–7% (12–15). Dyslipidaemia may contribute to PE as changes in plasma lipids may induce endothelial disturbances (16). This study therefore investigated the lipidaemic status, and the number of women with GDM who have PE.

Subjects and Methods

Subjects

An observational retrospective study in pregnant patients admitted to maternity wards of the University Hospital of the West Indies was conducted between January 2005 and December 2006. The test population consisted of 84 women with GDM and 94 women with normal glucose tolerance (controls) in the third trimester of pregnancy. Subjects were matched by gestational age. This study was approved by the University of the West Indies Ethics Committee. Inclusion criteria for enrollment included GDM according to the diagnostic criteria of the Third International Conference on Gestational Diabetes (2); gestational age between 28 and 34 weeks as determined by a clinical examination before 12 weeks and/or an ultrasound before 20 weeks; entry fasting serum glucose concentration of 7.2 mmol/L and no history of hypertension, renal, or other chronic medical disease; and negative antipancreatic islet cell antibodies. The patients were instructed to continue their usual diets and physical activities.

Gestational diabetes mellitus is usually detected in the second trimester; however since the prevalence of diabetes in Jamaica is high and can pre-date the pregnancy (17), it was important to screen for diabetes early in the first trimester. Fasting plasma glucose is used to eliminate women being classified as GDM whose diabetes might likely antedate their pregnancy (18). All women in the study were screened at nine weeks of gestation for glucose intolerance using the 50 g glucose O'Sullivan Test (5). Women with plasma glucose concentrations ≥ 7.8 mmol/L subsequently underwent 75 g of oral glucose tolerance test (OGTT), with threshold plasma glucose concentrations of 5.3, 10.2, and 8.6 mmol/L for fasting, 1 hour and 2 hour respectively (19). The O'Sullivan Test was repeated at 24–28 weeks of gestation on participants with normal O'Sullivan test results or OGTT results. The diagnosis of GDM was based on the World Health Organization's OGTT criteria (19) because the revised criteria do not affect the prevalence of GDM (20). The O'Sullivan test was repeated at 32 weeks of gestation on participants with normal O'Sullivan or OGTT results.

Blood pressure

Blood pressure was taken by qualified obstetric nurses using a mercury sphygmomanometer and stethoscope. Measurements were taken from the left upper arm after subjects had been sitting for >5 min in accordance with the recommendation of the American Heart Association (21). Triplicate measurements were taken with a 5 min rest interval between measurements and the mean value was recorded.

Hypertension in pregnancy is defined as the presence of a blood pressure of 140/90 mmHg taken twice 6 hours apart or a rise of 30 mmHg in systolic pressure or 15 mmHg in diastolic pressure (22). The first and fifth Korotkoff auscultatory sounds were used to determine the systolic and diastolic components. Preeclampsia is defined as hypertension associated with excretion of more than 300 mg of urinary protein per 24 hours or a rise in serum uric acid level of more than 1 mg per deciliter, a decrease in the platelet count of more than 50,000 per cubic millimeter, or both (23, 24). The classification followed the guidelines of the American College of Gynaecology and Obstetrics (25).

Biochemical analysis

Biochemical assays on the serum were performed with a multichannel autoanalyzer (c8000, Abbott Diagnostics, USA). Parameters that were determined include: total cholesterol (TC), triglycerides (TG), high density lipoprotein cholesterol (HDL-C), low density lipoprotein cholesterol (LDL-C), very low density lipoprotein cholesterol (VLDL-C). Serum LDL-C was calculated by Frederickson-Friedewald's formula according to which LDL-C = TC– (HDL-C + VLDL-C). Calculation of VLDL-C was 1/5 of triglyceride concentration. Total cholesterol was determined by an enzymatic method (26), and triglyceride by an analytical methodology based on the sequence of reaction described by Fossati and colleagues (27). The atherogenic index (AI) was calculated as [(TC – HDL-C)/HDL-C] (28). The methods adopted by the automated instrument for the determination of the above parameters are according to the manufacturer's instruction–Abbott Laboratories (Abbott Diagnostics, Illinois, USA).

Serial venous blood samples were collected and assayed for serum levels of urea and electrolytes, albumin, calcium, magnesium, phosphorous, uric acid, urea and creatinine utilizing a multi-channel autoanalyzer (c8000, Abbott Diagnostics, USA).

Statistical analysis

Values for the continuous variables are expressed as mean ± SEM. Comparisons of women with GDM against the control group were performed using unpaired students t tests, a level of $p < 0.05$ was considered as statistically significant. Data was analyzed by the Student's t-test for independent samples and the Fisher test for independent test with the level of significance set at 5%. Statistical significance was also assessed by the Mann-Whitney U test (29). Statistics were computed using SPSS 11.5 (SPSS Inc., Chicago, Illinois, United States).

Results

The two study groups were of similar maternal and gestational age, systolic and diastolic blood pressures (SBP and DBP, *Table I*). Women with GDM had significantly higher parity ($p=0.047$); but difference in gravida, birth weight of infant, haemoglobin concentrations were not significantly different from healthy pregnant controls ($p>0.05$). As expected, women with GDM had higher mean fasting, 1h, and 2h blood glucose concentrations compared with controls ($p=0.001$; *Table II*); mean HbA1c concen-

Table I Clinical characteristics of women with GDM and controls.

Biochemical parameters	GDM	Control	p value
Maternal age (yrs)	30.18 ± 0.88	29.61 ± 1.03	0.474
Gestational age (weeks)	38.29 ± 0.28	38.23 ± 0.79	0.946
SBP (mmHg)	116.54 ± 1.82	115.23 ± 2.29	0.651
DBP (mmHg)	72.81 ± 1.28	71.59 ± 1.91	0.582
Gravida (number)	2.86 ± 0.07	1.96 ± 0.20	0.063
Parity (number)	1.10 ± 0.16	0.62 ± 0.15*	0.047
Birth weight (kg)	3.09 ± 0.08	3.15 ± 0.09	0.655
Haemoglobin (g/L)	11.36 ± 0.17	11.09 ± 0.21	0.316

Data are presented as Mean ± S.E.
*P < 0.05 GDM group compared with controls.

Table Ii Biochemical parameters of women with GDM and control.

Biochemical parameters	GDM	Control	p value
Sodium (mmol/L)	134.66 ± 0.34	135.86 ± 0.27	0.080
Potassium (mmol/L)	3.83 ± 0.07	3.77 ± 0.07	0.409
Chloride (mmol/L)	107.13 ± 0.47	108.17 ± 1.29	0.550
Urea (mmol/L)	2.68 ± 0.15	3.25 ± 0.92	0.389
Bicarbonate (mmol/L)	17.00 ± 0.42	17.01 ± 1.74	0.644
Creatinine (μmol/L)	65.15 ± 3.33	63.84 ± 1.74	0.702
Total protein (g/L)	65.87 ± 1.93	66.31 ± 1.25	0.847
Albumin (g/L)	35.26 ± 0.83	33.62 ± 0.55	0.950
Globulins (g/L)	30.33 ±1.46	32.35 ± 1.01	0.263
Uric acid (mmol/L)	0.39 ± 0.04	0.31 ± 0.02	0.146
Total bilirubin (μmol/L)	5.23 ± 0.47	6.42 ± 0.92	0.069
Direct bilirubin (μmol/L)	2.16 ± 0.21	2.48 ± 0.31	0.001
ALP (U/L)	111.62 ± 11.32	116.77 ± 12.76	0.137
GGTP (U/L)	28.62 ± 4.50	19.23 ± 2.19	0.656
AST (U/L)	21.29 ± 2.23	27.46 ± 3.54	0.873
CPK (U/L)	80.95 ± 10.19	113.95 ± 12.67	0.110
LDH (U/L)	203.76 ± 14.40	183.35 ± 14.14	0.895
HBA1c (%)	5.90 ± 0.34	4.60 ± 0.67	0.001
Glucose (F) (mmol/L)	5.50 ± 0.20**	4.60 ± 0.38	0.001
Glucose (1 h) (mmol/L)	9.69 ± 0.43**	4.80 ± 0.33	0.001
Glucose (2 h) (mmol/L)	8.54 ± 0.42**	4.03 ± 0.38	0.001
Calcium (mmol/L)	2.17 ± 0.03	2.15 ± 0.03	0.239
Phosphorous (mmol/L)	1.24 ± 0.06	1.18 ± 0.06	0.581
Magnesium (mmol/L)	0.79 ± 0.02	0.82 ± 0.02	0.200

Data are presented as Mean ± S.E.
**P < 0.01 GDM group compared with controls.

Table III Blood lipids of women with GDM and controls.

Lipid parameters	GDM	Control	p value
Total cholesterol (mmol/L)	5.71 ± 0.24*	5.01 ± 0.32	0.039
Triglyceride (mmol/L)	1.83 ± 0.10*	1.43 ± 0.20	0.033
HDL-cholesterol (mmol/L)	1.25 ± 0.08	1.45 ± 0.08	0.086
VLDL-cholesterol (mmol/L)	0.34 ± 0.02	0.33 ± 0.05	0.799
LDL-cholesterol (mmol/L)	3.32 ± 0.24	3.05 ± 0.34	0.727
Atherogenic index	3.19 ± 0.24	3.14 ± 0.35	0.904
LDL-C : HDL-C ratio	2.71 ± 0.23	2.67 ± 0.29	0.926
TC : HDL-C ratio	3.35 ± 0.23	3.23 ± 0.11	0.990
TG : HDL-C ratio	1.24 ± 0.08	1.21 ± 0.20	0.900
HDL-C : VLDL-C ratio	3.75 ± 0.40	3.95 ± 0.25	0.571

Data are presented as Mean ± S.E.
*P < 0.05 GDM group compared with controls.

Table IV Clinical characteristics of women with GDM and GDM-PE.

Biochemical parameters	GDM	GDM-PE	p value
Maternal age (yrs)	30.32 ± 0.96	28.83 ± 2.83	0.530
Gestational age (weeks)	38.30 ± 0.27	38.00 ± 1.32	0.733
SBP (mmHg)	115.44 ± 1.73	130.00 ± 2.66*	0.015
DBP (mmHg)	71.98 ± 1.33	78.83 ± 2.83	0.073
Gravida (number)	2.50 ± 0.21	4.00 ± 0.33*	0.047
Parity (number)	1.09 ± 0.18	1.20 ± 0.37	0.882
Birth weight (kg)	3.12 ± 0.08	2.58 ± 0.54*	0.025
Proteinuria (g/day)	0.09 ± 0.01	1.02 ± 0.11**	0.001
Haemoglobin (g/L)	11.41 ± 0.17	11.10 ± 0.70	0.316

Data are presented as Mean ± S.E.
*P < 0.05 GDM-PE group compared with GDM group; **P < 0.01 GDM-PE group compared with GDM group.

Table V Biochemical parameters of women with GDM and GDM-PE.

Biochemical parameters	GDM	GDM-PE	p value
Sodium (mmol/L)	134.63 ± 0.38	134.83 ± 0.75	0.841
Potassium (mmol/L)	3.78 ± 0.07	4.20 ± 0.13*	0.032
Chloride (mmol/L)	107.18 ± 0.53	106.83 ± 0.95	0.797
Urea (mmol/L)	2.69 ± 0.17	2.63 ± 0.18	0.902
Bicarbonate (mmol/L)	17.02 ± 0.47	16.83 ± 0.54	0.881
Creatinine (μmol/L)	65.67 ± 3.37	72.17 ± 7.90	0.481
Total protein (g/L)	65.96 ± 2.29	66.31 ± 1.25	0.104
Albumin (g/L)	35.54 ± 0.97	33.62 ± 0.55	0.449
Globulins (g/L)	30.12 ±1.64	32.35 ± 1.01	0.750
Uric acid (mmol/L)	0.37 ± 0.04	0.28 ± 0.03	0.327
Total bilirubin (μmol/L)	5.23 ± 0.47	6.42 ± 0.92	0.275
Direct bilirubin (μmol/L)	2.25 ± 0.31	2.48 ± 0.31	0.564
ALP (U/L)	103.38 ± 13.67	141.80 ± 15.41	0.231
LDH (U/L)	223.38 ± 17.70	196.00 ± 11.37	0.611
Calcium (mmol/L)	2.10 ± 0.03	2.29 ± 0.06**	0.003
Phosphorous (mmol/L)	1.13 ± 0.06	1.30 ± 0.08	0.162
Magnesium (mmol/L)	0.60 ± 0.05	0.85 ± 0.02	0.208

Data are presented as Mean ± S.E.
*P < 0.05 GDM-PE group compared with GDM group; **P < 0.01 GDM-PE group compared with GDM group.

tration was also significantly higher in women with GDM (p=0.001).

From the lipid profile, women with GDM had significantly higher total cholesterol (p=0.039) and triglyceride concentrations (p=0.033), but non-significantly lower HDL-cholesterol (p=0.086) compared with controls (*Table III*). LDL-cholesterol, atherogenic index, and TC:HDL-cholesterol ratio were higher in women with GDM-PE compared with women with only GDM; however, these differences did not attain significance.

Gestational age, maternal age, parity and haemoglobin concentration were similar in women with GDM and those with GDM-PE (*Table IV*). Systolic

Table VI Blood lipids of women with GDM and GDM-PE.

Lipid parameters	GDM	GDM-PE	p value
Total cholesterol (mmol/L)	5.08 ± 0.32	6.00 ± 0.62	0.185
Triglycerides (mmol/L)	1.47 ± 0.10	2.13 ± 0.21*	0.020
HDL-cholesterol (mmol/L)	1.59 ± 0.10	1.35 ± 0.07	0.194
VLDL-cholesterol (mmol/L)	0.32 ± 0.02	0.43 ± 0.04*	0.037
LDL-cholesterol (mmol/L)	3.09 ± 0.26	3.43 ± 0.70	0.572
Atherogenic index	3.09 ± 0.28	3.62 ± 0.52	0.291
LDL-C : HDL-C ratio	2.55 ± 0.26	2.99 ± 0.31	0.476
TC : HDL-C ratio	3.51 ± 0.28	3.82 ± 0.52	0.580
TG : HDL-C ratio	1.08 ± 0.10	1.40 ± 0.23	0.262
HDL-C : VLDL-C ratio	3.96 ± 0.25	3.75 ± 0.40	0.485

Data are presented as Mean ± S.E.
*P < 0.05 GDM-PE group compared with GDM group

blood pressure (p= 0.015) and protein in the urine (p=0.001) were significantly elevated in women with GDM-PE, and the mean birth weight of infants born to women with GDM-PE was significantly lower than that of women with only GDM (p=0.025). Women with GDM-PE had significantly higher gravida (p=0.047); however, even though DBP was higher in women with GDM-PE, it did not attain significance (*Table IV*). Women with GDM-PE had significantly lower mean potassium (p=0.032) and calcium (p=0.003) concentrations compared with controls, although these values fall within the normal reference ranges (*Table V*). Alkaline phosphatase (ALP) and lactate dehydrogenase (LDH) activities were higher in women with GDM-PE compared with women with only GDM; however, the differences were not significant.

Triglyceride (p=0.020) and VLDL-cholesterol concentrations (p=0.037) were significantly elevated in patients with GDM-PE when compared to women with only GDM (*Table VI*). Women with GDM-PE had higher total cholesterol, LDL-cholesterol, atherogenic index and LDL-cholesterol:HDL-cholesterol ratio, total cholesterol:HDL-cholesterol ratio; however, these were not significantly different from women with only GDM (p> 0.05).

Discussion

This study revealed that women with GDM have significantly elevated serum total cholesterol and triglyceride concentrations compared to pregnant women with normal glucose tolerance. Women with GDM also have higher LDL-cholesterol and atherogenic index but lower HDL-cholesterol. However, these differences were not statistically significant. Ten of the eighty four (11.9%) women with GDM had preeclampsia. Systolic blood pressure was significantly elevated in women with GDM-PE, and the mean birth weight of infants born to women with GDM-PE was significantly lower than that of women with only GDM. Women with GDM-PE had significantly lower serum potassium and calcium concentrations compared to women with only GDM, although these values fall within the normal reference ranges.

High serum oestrogen concentrations and increasing insulin resistance in late pregnancy are considered to be responsible for the hypertriglyceridaemia observed during normal pregnancy. Cholesterol is used by the placenta for steroid synthesis and fatty acids are used for placental oxidation and membrane formation (30). Changes in total cholesterol concentration reflect changes in the various lipoprotein fractions. Total and LDL-cholesterol concentrations decreased initially, but then increased in the second and third trimesters. HDL-cholesterol increased by the 12th week of gestation in response to oestrogen and remains elevated throughout pregnancy (30). VLDL-cholesterol and triglycerides decreased in the first 8 week of gestation and then continuously increased until full term. In the second half of pregnancy, VLDL-cholesterol clearance is altered because of the decreased activity of lipoprotein lipase (LPL) in the adipose and liver and because of the increased activity in the placenta (30).

The abnormalities of carbohydrate metabolism observed in GDM may lead to other abnormalities (most commonly the typical abnormalities seen in insulin resistance), especially lipid abnormalities. Metabolic studies carried out demonstrated that women with GDM have multiple defects in insulin action together with impaired compensation for insulin resistance. These defects in the regulation of glucose production, glucose clearance and free fatty acid concentrations, along with defects in pancreatic β-cell function, precede the development of type 2 diabetes in women with GDM. Insulin resistance and type 2 diabetes mellitus are associated with a clustering of interrelated plasma lipid and lipoprotein abnormalities, which include elevated triglyceride concentrations, decreased HDL-cholesterol and a predominance of LDL-cholesterol particles (31). This dyslipidaemic profile has also been noted in pregnancies complicated by GDM in various case control studies (32–34). However, not all results from these studies are in consonant with each other. The dyslipidaemia profile observed in our study is not in accordance with reports from some other investigations. Knopp and colleagues studied 22 women with GDM and 38 controls in the third trimester of pregnancy (35). These authors found increased plasma concentrations of triglycerides and VLDL-cholesterol but no difference in plasma cholesterol concentrations in women with GDM (35). Montelongo and colleagues in their study also reported no differences in total cholesterol and triglyceride between women with GDM and controls in their first, second or third trimester (36). In addition, Bartha and colleagues reported that maternal total cholesterol and triglyceride concentrations were similar in GDM and normal pregnancy (33). In our study, the LDL-cholesterol concentration in women with GDM was higher than in controls but there was no significant difference. The discrepancies among studies may be the result of false negative tests of the null hypothesis in studies with smaller sample sizes, as well as other methodological differences (37).

In this study, the triglyceride concentration was significantly elevated in women with GDM with higher LDL-cholesterol and VLDL, although these were not statistically significantly different from the controls. The hypertriglyceridaemia seen in controls and those with GDM who had a family history of early onset autosomal dominant type 2 diabetes may be due to defective lipolysis of very LDL-triglyceride (38, 39). A large number of mutations in lipoprotein lipase (LPL) have been identified and these can cause hypertriglyceridaemia (40). However, it is doubtful that most cases of endogenous hypertriglyceridaemia can be explained by mutations in LPL, which appear to be relatively rare. Decreased LDL catabolism may account for the rise in plasma LDL-cholesterol concentration (36).

Gestational diabetes mellitus is relatively common and affects 3–5 percent of pregnancies, resulting in a variety of complications that primarily affect the foetus, including macrosomia, stillbirth, jaundice, and respiratory distress syndrome (41). Like GDM, hypertensive disorders of pregnancy complicate 5–10 percent of all pregnancies and can result in a variety of maternal and foetal complications, including seizures, stroke, hepatic failure, renal failure, intrauterine growth retardation, foetal distress, premature delivery, and death (42). The pathophysiology of pregnancy-induced hypertension (PIH) is poorly understood, but it is likely multifactorial; several lines of evidence suggest that glucose intolerance and insulin resistance have a role in the etiology of these diseases (43).

The findings of this study revealed that 11.9% of women with GDM had PE (GDM-PE). This value falls within the range of 10–30% reported by a number of investigators (12–15). Women with GDM-PE had significantly elevated triglycerides and VDL-cholesterol compared to women with only GDM. In addition, women with GDM-PE had higher total cholesterol, atherogenic index, LDL-cholesterol:HDL-cholesterol ratio, total cholesterol:HDL-cholesterol ratio and triglyceride:HDL-cholesterol ratio, but these were not significantly different from women with only GDM. Women with GDM-PE had infants with significantly lower birth weights compared with women with only GDM. A possible explanation of this finding is that preeclampsia of early onset (≤37 weeks) may be more likely to be severe, have a detrimental effect on fetal growth, and lead to iatrogenic premature delivery. Preeclampsia that is of late onset (> 37 weeks) may be more likely to be mild and less likely to lead to iatrogenic premature delivery (44).

The elevated triglyceride concentrations in women with GDM-PE could be explained by overproduction of VLDL in the liver due to hyperlipidaemia and resistance of lipoprotein lipase to insulin action which is a characteristic feature of the insulin-resistance syndrome (45). The VLDL-cholesterol concentration as reported by some researchers might increase up to 2.5 folds at term over the pre-pregnancy concentrations (46, 47). The VLDL-cholesterol increased even further in preeclampsia perhaps due to increased VLDL lipoproteins, which accumulate over the maternal vascular endothelium particularly those of the uterine and renal vessels (48). Further VLDL-cholesterol may cause injury to the endothelium, while a specific toxicity-preventing-activity-protein (the pI 5.6 form of plasma albumin) protects against VLDL-induced injury in the pathogenic process of toxaemia (49).

The relation between PIH and GDM is not well understood. While there are several studies that have suggested an association between these diseases (50–52), there are those which have not found any association (53, 54). One cohort study of 10,666 women in Sweden examined risk factors for gestational hypertension and PE (55). This study reported a significantly 3.16-fold increased risk of PE among

mothers with gestational diabetes compared with mothers without gestational diabetes, but it was unable to demonstrate a statistically significant 1.34-fold increased risk of gestational hypertension (55). A prospective study of women participating in a calcium supplementation trial for the prevention of PE also demonstrated that the degree of abnormal glucose tolerance was associated with PE (56). This study also suggested that women with gestational diabetes have a 1.67-fold increased risk of developing PE (56). A French study of 15 maternity units also found an association between gestational diabetes and a significantly 2.86-fold increased risk of developing PIH among women with gestational diabetes (57).

This study was carried out in a black population. Interactions such as ethnicity and the development of PIH were not investigated in this study. A study by Bryson and colleagues found interactions between ethnicity and gestational diabetes regarding their association with eclampsia and severe preeclampsia. The risk of PIH associated with gestational diabetes was highest among mothers of black ethnicity, followed by Hispanic and Caucasian. They also suggested that both ethnicity and prenatal care modified the association between gestational diabetes and PIH (58).

It was found that GDM is associated with hyperlipidaemia as evidenced by the significantly elevated total cholesterol and triglyceride concentrations. Dyslipidaemia in women with gestational diabetes increases their risk of developing PE. These findings should greatly contribute to the understanding of the afforementioned disorders. It is imperative that blood lipids be evaluated in women with GDM during antenatal care since it would be helpful in the early detection and treatment of PE.

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