Am J Transl Res 2024;16(7):3117-3128
www.ajtr.org /ISSN:1943-8141/AJTR0156428

Original Article

Correlation between lipid levels at different stages of pregnancy and pregnancy outcome and complications

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Received March 8, 2024; Accepted June 11, 2024; Epub July 15, 2024; Published July 30, 2024

Abstract: Objective: To explore correlation between lipid levels at different stages of pregnancy and outcomes and complications of pregnancy. Methods: The clinical data of 1000 parturients were retrospectively analyzed. The incidence of perinatal complications was counted, and the blood lipid levels of pregnant women with and without complications during pregnancy were compared. Additionally, the pregnancy outcomes of women with different lipid levels were compared. Results: There were statistically significant differences in total cholesterol (TC), triglyceride (TG), and low-density lipoprotein cholesterol (LDL-C) levels among early, mid, and late pregnancy (all $P < 0.05$). Single-factor analysis showed that TG in the complication group was higher than that of the non-complication group, while high-density lipoprotein cholesterol (HDL-C) was lower (both $P < 0.05$). Dyslipidemia was detected in 932 (95.20%) of cases in the complication group and 19 (90.48%) cases in the non-complication group, with no significant difference between the groups (P=0.630). There was also no significant difference in the incidence of adverse pregnancy outcome between the dyslipidemia and non-dyslipidemia groups (P=0.396). Multifactor analysis showed that TC, TG, HDL, and LDL-C in the first, second, or third trimesters were not risk factors for complications or adverse pregnancy outcome ($P > 0.05$). Correlation analysis indicated that TC, TG, HDL-C, and LDL-C in the first, second, and third trimesters of pregnancy had no significant correlation with the number of complications (First trimester: r=0.099, 0.146, -0.106, 0.137; Second trimester: r=0.027, 0.152, -0.102, 0.009; Third trimester: r=0.031, 0.191, -0.064, -0.056). Conclusion: The serum lipid levels of pregnant women increased significantly in the second and third trimesters. However, there was no correlation between these elevated serum lipid levels and pregnancy complications or adverse outcome.

Keywords: Pregnancy, lipid level, complications, outcomes, correlation

Introduction

A normal fetus relies on the mother's intake of nutrients for growth and development. With the rising of economic levels, the focus on the nutrition of pregnant women has intensified. Pregnancy induces significant metabolic changes in women to accommodate fetal growth and development. Consequently, as women's physical fitness improves during pregnancy, the prevalence of complications such as hypertension, diabetes, premature rupture of membranes, severe preeclampsia, and thrombocytopenia has increased, posing hidden risks to maternal and infant health [1]. To support fetal development, the mother undergoes various adaptive changes, including enhanced nutrient absorption by the digestive system, leading to increased blood lipid levels [2]. Fats and amino acids are essential during pregnancy for the normal development of cellular structures and enzymatic activities, serving to maintain fetal growth and reserve energy for pregnancy, childbirth, and postpartum breastfeeding [3]. However, abnormal lipid metabolism leading to obesity can result from continuous exposure to a high-fat diet, possibly causing fetal overgrowth and increasing the risk of adverse pregnancy outcomes such as fetal distress, premature birth, fetal macrosomia, and neonatal hypoglycemia, thereby seriously endangering the health of both mother and child [4]. Current research indicates a correlation between lipid levels during pregnancy and maternal and

https://doi.org/10.62347/OJVV2986

infant outcomes, although data supporting this connection are limited, particularly in China [5]. Thus, this study aims to analyze thoroughly the correlation between lipid levels at different stages of pregnancy and complications as well as outcomes of pregnancy, providing insight for perinatal healthcare.

Materials and methods

Sources

This retrospective analysis used clinical data from 1000 puerperae who had prenatal examinations and in-hospital deliveries at the Department of Obstetrics of Hunan Maternal and Child Health Hospital between May 2020 and April 2022. Inclusion criteria included: (1) routine obstetric check-ups throughout pregnancy; (2) complete lipid profile results from the first, second, and third trimesters; (3) singleton pregnancies only. Exclusion criteria were: (1) pre-existing hypothyroidism; (2) history of hypertension, diabetes, or liver disease; (3) intake of therapeutic drugs or pesticides during the first month of pregnancy. The study received approval from the Medical Ethics Committee of Hunan Maternal and Child Health Hospital.

Methods

Five mL of peripheral venous blood was collected from fasting pregnant women during the first trimester (8 to 12 weeks), second trimester (24 to 28 weeks), and third trimester (36 weeks to before the onset of labor). Blood samples were left at room temperature for 30 minutes before being centrifuged at 3000 rpm for 5 minutes. The precipitate was discarded, and the supernatant was analyzed. Levels of total cholesterol (TC, LOT: EXP20062024), triglycerides (TG, LOT: EXP10072024), high-density lipoprotein cholesterol (HDL-C, LOT: EXP25032024), and low-density lipoprotein cholesterol (LDL-C, LOT: EXP13052024) were measured using a BIOBASE BK-400 fully automated biochemical analyzer, supplied by Shanghai Qitai Biology Science and Technology Co., Ltd. The study counted the incidence of perinatal complications and compared the lipid levels and pregnancy outcomes between women with and without pregnancy complications.

Assessment criteria

(1) Dyslipidemia assessment was based on Guidelines for Prevention and Treatment of Dyslipidemia in Adults in China *(2016 revised edition)* [6]. Normal lipid levels are defined as follows: TC: < 5.20 mmol/L; TG: < 1.70 mmol/L; LDL-C: < 3.40 mmol/L; HDL-C: 0.91-1.55 mmol/L. (2) Pregnancy complications assessed included hyperlipidemia, anemia, fetal distress, hydramnios, premature rupture of membranes, postpartum infection, gestational hypertension, gestational diabetes mellitus, subclinical hypothyroidism during pregnancy, severe preeclampsia, thrombocytopenia, and hypokalemia. Diagnostic criteria included: Hydramnios was diagnosed based on ultrasound findings before delivery, Hydramnios: Ultrasound which include a cumulative depth of amniotic fluid across four quadrants totaling ≥ 25 cm, the depth of the largest a single pocket depth ≥ 8 cm, or a total amniotic fluid volume of ≥ 2 L post-delivery [7]. Premature rupture of membranes is characterized by regular and progressively intense uterine contractions that last at least 30 seconds and occurs every 5 to 6 minutes [8]. It is associated with cervical effacement, dilation, and fetal malposition. Postpartum infection is characterized by a body temperature of ≥ 38°C with a white blood cell count exceeding 10×10^9/L [9]. Gestational diabetes mellitus (GDM) is diagnosed based on the results of an: oral glucose tolerance test. The criteria for a GDM diagnosis include a fasting plasma glucose level of ≥ 5.1 mmol/L, a 1-hour plasma glucose level of ≥ 10.0 mmol/L, or a 2-hour plasma glucose level of ≥ 8.5 mmol/L [10]. (3) Adverse pregnancy outcomes include premature birth, fetal macrosomia, low birth weight, infant deformities, neonatal hypoglycemia, and fetal distress. Fetal distress is identified by specific criteria including a fetal heart rate exceeding 180 beats per minute or below 120 beats per minute for more than 10 minutes [11]. Additionally, significant contamination of the amniotic fluid (III degree) and the presence of variable or late decelerations in fetal heart rate monitoring are also indicative of fetal distress.

Premature birth is defined as a birth occurring between 28 and less than 37 weeks of gestation [12].

Fetal macrosomia is termed as a fetal weight of 4 kg or more [13].

Neonatal hypoglycemia is identified when the plasma glucose level of a newborn is less than 2.2 mmol/L within 30 minutes of birth [14].

Statistical analysis

Statistical analyses were performed using SPSS version 23.0. Quantitative data were expressed as mean ± standard deviation ($\overline{x} \pm s$). The independent sample t-test was employed to compare mean differences between two groups, while ANOVA was utilized for comparisons among more than two groups. Qualitative data were expressed as frequency and percentage (n%), tested by chi-square test. A corrected four-grid table was used for chi-square tests with theoretical frequencies between 1 and 5. Fisher's exact test was applied where theoretical frequencies were zero. Multifactor logistic regression analysis was conducted for risk factor assessment, and Spearman correlation analysis was used for correlation testing. The significance threshold (α) was set at 0.05. A *P*-value < 0.05 was considered significant.

Results

Comparison of basic data

The study participants were categorized based on the presence of pregnancy complications, with 979 cases in the complication group and 21 cases in the non-complication group. They were also grouped based on dyslipidemia status, with 951 cases in the dyslipidemia group and 49 cases in the non-dyslipidemia group. As shown in **Table 1**, the complication group had a significantly higher average age, a lower total weeks of pregnancy, and a lower proportion of vaginal deliveries compared to the non-complication group (all $P < 0.05$). Compared to group the non-dyslipidemia group, the dyslipidemia group had a higher average newborn weight (all $P < 0.05$).

Lipid levels at different stages of pregnancy

Table 2 shows that there were statistically significant differences in levels of TC, TG, and LDL-C across the first, second, and third trimesters of pregnancy (all $P < 0.05$).

Comparison of lipid levels and pregnancy complications

According to **Table 3**, complications group had significantly lower HDL-C levels compared to the non-complicated group in the second trimester ($P < 0.05$). In late pregnancy, the complication group showed higher TG levels and lower HDL-C levels than the non-complication group (all $P < 0.05$). The prevalence of dyslipidemia was 95.20% in the complication group and 90.48% in the non-complication group, with no significant difference in detection rates between the groups (χ^2=0.232, *P*=0.630).

Comparison of adverse pregnancy outcomes and presence of dyslipidemia

No significant differences were observed in the incidence of adverse pregnancy outcomes between the dyslipidemia and non-dyslipidemia groups (χ^2=0.721, *P*=0.396). See **Table 4**.

Multifactor logistic regression analysis

The logistic regression analysis included blood lipid levels and general data as independent variables, with the occurrence of complications and adverse pregnancy outcomes as dependent variables. After adjusting for age, pre-pregnancy BMI, pregnancy weight gain, maternal education level, gestational weeks, newborn weight, and delivery mode, the levels of TC, TG, HDL-C, and LDL-C in the first, second, and third trimesters were not found to be risk factors for complications or adverse pregnancy outcomes (all $P > 0.05$) (**Tables 5** and **6**).

Correlation analysis

Spearman correlation analysis was conducted to assess the relationship between blood lipid indices and the number of complications. The findings indicated no significant correlation between TC, TG, HDL-C, and LDL-C levels in the first, second, and third trimesters and the number of complications (First trimester: r=0.099, 0.146, -0.106, 0.137; Second trimester: r=0.027, 0.152, -0.102, 0.009; Third trimester: r=0.031, 0.191, -0.064, -0.056) (**Table 7**; **Figure 1**).

Discussion

Normal lipid metabolism is essential for providing the energy needed for fetal growth and

Table 1. Comparison of basic data

Item	Complication group (n=979)	Non-complication group (n=21)	t/χ^2	*P*	Dyslipidemia group (n=951)	Non-dyslipidemia (n=49)	t/χ^2	*P*
Age ($\bar{x}$ ± s; years old)	31 (28, 33)	28 (27, 31.5)	-2.651	0.008	31 (28, 33)	30.61±3.80	-0.634	0.526
BMI before pregnancy ($\bar{x}$ ± s; kg/m^2)	21.2 (19.5, 23.2)	21.32±2.11	-0.053	0.958	21.3 (19.50, 23.20)	20.88±2.75	-1.739	0.082
Weight gain during pregnancy ($\bar{x}$ ± s; kg)	13.0 (10.0, 16.0)	14.33±4.29	-0.953	0.340	13.0 (10.0, 16.0)	12.5 (9.75, 15)	-1.688	0.091
Education level of pregnant women (n, %)			0.207	0.649			0.048	0.827
High school education or less	100 (10.21)	1 (4.76)			97 (10.20)	4 (8.16)		
Junior college education or above	879 (89.79)	20 (95.24)			854 (89.80)	45 (91.84)		
Total weeks of pregnancy ($\bar{x}$ ± s; weeks)	39 (38, 40)	40 (39, 40)	-2.586	0.010	39 (38, 40)	38.88±1.22	-0.289	0.772
Newborn weight (g)	3300 (3000, 3600)	3276.19±471.86	-0.668	0.504	3300 (3000, 3600)	3100 (2950, 3425)	-2.520	0.012
Birthing Methods (n, %)			6.527	0.038			1.521	0.467
Vaginal delivery	428 (43.72%)	11 (52.38%)			416 (43.74%)	23 (46.94%)		
Episiotomy	454 (46.37%)	5 (23.81%)			440 (46.27%)	19 (38.78%)		
Caesarean delivery	97 (9.91)	5 (23.81%)			95 (9.99%)	7 (14.29%)		

Note: BMI: Body Mass Index.

Table 2. Lipid levels at different stages of pregnancy (x ± sd; mmol/L)

Lipid indicator	First trimester	Second trimester	Third trimester	F	*P*
TC	4.45 (3.96, 5.00)	5.66 (4.96, 6.35)	6.13±1.17	1102.228	< 0.001
TG	1.47 (1.17, 1.95)	2.53 (1.94, 3.33)	3.49 (2.84, 4.50)	1432.331	< 0.001
HDL-C	1.76 (1.49, 2.05)	1.79 (1.52, 2.05)	1.68 (1.46, 1.91)	78.954	< 0.001
LDL-C	2.34 (1.96, 2.79)	2.98 (2.42, 3.52)	3.13 (2.42, 3.76)	584.825	< 0.001

Note: TC: total cholesterol; TG: triglyceride; HDL-C: high density lipoprotein cholesterol; LDL-C: low density lipoprotein cholesterol.

development [15]. Studies suggested that a high third-trimester TG level is a significant contributor to newborn weight gain [16]. This study observed that 97.9% (979/1000) of the participants experienced pregnancy complications and 95.1% (951/1000) of them exhibited dyslipidemia rates which are higher than previously reported [17]. Increased lipid absorption by the maternal digestive system during pregnancy is necessary to meet fetal nutritional needs, possibly leading to elevated lipid levels and dyslipidemia [18].

The data on lipid levels in pregnant women at different stages of pregnancy in this study indicate that, in the first trimester, lipid levels were generally within the normal range. However, in the second and third trimesters, there were significant increases in levels of TC, TG, and LDL-C, characteristic of hyperlipidemia type IV, aligning with findings by Ryckman et al. [19]. Unlike previous studies, fluctuations in HDL-C in the second and third trimesters were less pronounced than other lipid indicators. This finding may be related to the dietary habits of the participants. The literature on this specific aspect is limited, necessitating further investigation.

The observed increases in TC, TG, and LDL-C in the second and third trimesters could be attributed to elevated secretion of hormones such as progesterone, estrogen, growth hormone, glucagon, and insulin in pregnant women. These hormones activate hormone-sensitive lipase and promote hepatic LDL-C production [20]. Additionally, enhanced intestinal fat absorption in the third trimester contributes to hyperlipidemia. Factors such as high-fat and high-protein diets, coupled with reduced physical activity during these stages, further elevate lipid levels [21].

Relevant studies have found that elevated mid-pregnancy TG levels are associated with higher glucose and fat levels and more severe insulin resistance at the time of measurement, indicating a link between TG levels during pregnancy and postpartum metabolic status [22]. Other research has shown that TG, TC, and LDL-C levels are positively correlated with gestational age, with lipid levels varying during the middle to late stages of pregnancy [23]. These fluctuations are likely due to dynamic changes in maternal glucose and lipid metabolism needed to support physiological adaptations and fetal growth and development. As gestational age increases, the fetal demand for nutrients such as glucose and lipids intensifies. Additionally, as early pregnancy nausea subsides and appetite increases in the second and third trimesters, excessive intake of fats and carbohydrates can lead to higher production of TC and TG. A prolonged high-fat diet during these trimesters results in excessive fat accumulation, which can be mobilized and released into the bloodstream, raising LDL-C levels.

This study found lower HDL-C levels in the second-trimester complications group compared to the uncomplicated group. In the late pregnancy complication group, TG levels were higher and HDL-C levels lower than those in the non-complication group. Notably, there was no significant difference in the detection rate of dyslipidemia between the complication group and the non-complication group (χ^2=0.232, P=0.630). These findings suggest that lipid levels at these stages of pregnancy are not associated with the occurrence of pregnancy complications, which contradicts the results of previous studies [24]. This indicates that lifestyle adjustments aimed at reducing blood lipids, such as changes in diet, weight management, and physical activity, may not be effective in preventing pregnancy complications and adverse outcomes.

Change in fat metabolism is one of the most pronounced metabolic changes during preg-

Table 3. Comparison of lipid levels at different stages of pregnancy between pregnant women in the complication and non-complication groups ($\bar{x}$ ± sd; mmol/L)

Stage of pregnancy	Lipid indicator	TC	TG	HDL-C	LDL-C
First trimester	Complication group (n=979)	4.44 (3.94, 4.99)	1.43 (1.11, 1.84)	1.70 (1.46, 1.98)	2.35 (1.97, 2.78)
	No complication group (n=21)	4.33±0.53	1.37±0.43	1.88±0.40	2.13 (1.925, 2.445)
	t	-0.706	-1.029	-1.614	-1.565
	P	0.480	0.303	0.107	0.118
Second trimester	Complication group (n=979)	5.68 (5, 6.33)	2.4 (1.88, 3.08)	1.88 (1.6, 2.15)	3.02 (2.49, 3.58)
	No complication group (n=21)	5.67±0.74	2.22 (1.80, 3.13)	2.10±0.45	3.01 (2.65, 3.26)
	t	-0.174	-0.165	-1.991	-0.637
	P	0.862	0.869	0.046	0.524
Third trimester	Complication group (n=979)	6.17 (5.42, 6.95)	3.41 (2.78, 4.41)	1.75 (1.52, 2.03)	3.24 (2.59, 3.88)
	No complication group (n=21)	6.25±0.99	2.85 (2.43, 3.41)	1.98 (1.72, 2.45)	3.25±0.87
	t	-0.099	-2.274	-2.859	-0.046
	P	0.922	0.023	0.004	0.963

Note: TC: total cholesterol; TG: triglyceride; HDL-C: high density lipoprotein cholesterol; LDL-C: low density lipoprotein cholesterol.

Table 4. Comparison of adverse pregnancy outcomes between pregnant women in the dyslipidemia group and non-dyslipidemia group

Lipid level	Premature birth	Fetal macrosomia	Low birthweight and neonatal hypoglycemia	Infant deformities and fetal distress	Hypoproteinemia	Metabolic acidosis or alkalosis	Hyperbilirubinemia	Number of adverse pregnancy outcomes
Dyslipidemia group (951)	28 (2.94)	70 (7.36)	15 (1.58)	19 (2.00)	9 (0.95)	21 (2.21)	167 (17.56)	603 (63.41)
Non-dyslipidemia group (49)	2 (4.08)	1 (2.04)	1 (2.04)	0 (0.00)	0 (0.00)	0 (0.00)	6 (12.24)	34 (69.39)
t	0.001	1.274	< 0.001	1.928	0.909	2.133	0.920	0.721
P	0.979	0.259	> 0.999	0.165	0.341	0.124	0.337	0.396

Table 5. Multivariate logistic regression analysis of maternal complications

Independent variable	B	S.E.	Wals	*P*	OR (95% CI)
Model 1					
First trimester					
TC	0.006	0.035	0.031	0.861	1.006 (0.940-1.077)
TG	0.068	0.376	0.033	0.857	1.070 (0.513-2.235)
HDL	0.016	0.058	0.073	0.788	1.016 (0.907-1.138)
LDL	0.353	0.501	0.497	0.481	1.424 (0.533-3.800)
Second trimester					
TC	0.001	0.021	0.002	0.967	1.001 (0.961-1.043)
TG	0.005	0.027	0.028	0.866	1.005 (0.953-1.059)
HDL	0.003	0.045	0.006	0.939	1.003 (0.919-1.096)
LDL	0.178	0.439	0.165	0.684	1.195 (0.506-2.825)
Third trimester					
TC	0.003	0.018	0.021	0.886	1.003 (0.968-1.038)
TG	0.367	0.224	2.698	0.100	1.444 (0.931-2.238)
HDL	0.006	0.034	0.026	0.872	1.006 (0.940-1.075)
LDL	-0.094	0.330	0.081	0.776	0.910 (0.476-1.739)
Model 2					
First trimester					
TC	0.005	0.032	0.024	0.876	1.005 (0.944-1.070)
TG	0.029	0.164	0.031	0.861	1.029 (0.746-1.419)
HDL	0.015	0.061	0.064	0.800	1.016 (0.901-1.144)
LDL	0.311	0.521	0.356	0.551	1.365 (0.492-3.786)
Second trimester					
TC	0.002	0.020	0.011	0.916	1.002 (0.963-1.043)
TG	0.006	0.027	0.044	0.835	1.006 (0.955-1.059)
HDL	0.002	0.045	0.002	0.967	1.002 (0.916-1.095)
LDL	0.296	0.470	0.397	0.529	1.345 (0.535-3.381)
Third trimester					
TC	0.003	0.016	0.030	0.862	1.003 (0.972-1.035)
TG	0.283	0.229	1.530	0.216	1.327 (0.847-2.080)
HDL	0.007	0.032	0.045	0.832	1.007 (0.945-1.073)
LDL	-0.079	0.350	0.051	0.821	0.924 (0.465-1.836)
Age	0.107	0.066	2.602	0.107	1.113 (0.977-1.267)
BMI before pregnancy	-0.063	0.083	0.577	0.447	0.939 (0.799-1.104)
Weight gain during pregnancy	-0.050	0.052	0.922	0.337	0.952 (0.860-1.053)
BMI before pregnancy	-0.510	0.243	4.387	0.036	0.601 (0.373-0.968)
Birthing methods			3.446	0.179	
Natural labor	0.747	0.581	1.653	0.199	2.110 (0.676-6.586)
Caesarean section	1.245	0.676	3.393	0.065	3.471 (0.923-13.049)
Newborn weight	0.001	0.001	1.202	0.273	1.001 (0.999-1.002)

Note: TC: total cholesterol; TG: triglyceride; HDL-C: high density lipoprotein cholesterol; LDL-C: low density lipoprotein cholesterol; BMI: body mass index.

nancy, resulting in hyperlipidemia in over 60% of pregnant women [25]. However, the results of this study did not confirm a significant correlation between maternal lipid levels and pregnancy complications or adverse outcomes, differing from prior research. For instance, Pan et al. [26] reported significant lipid metabolism abnormalities in the third trimester of GDM

Table 6. Multivariate logistic regression analysis of adverse maternal pregnancy outcomes

Independent variable	B	S.E.	Wals	*P*	OR (95% CI)
Model 1					
First trimester					
TC	-0.008	0.011	0.534	0.465	0.992 (0.971-1.014)
TG	-0.003	0.013	0.047	0.828	0.997 (0.973-1.022)
HDL	0.001	0.005	0.016	0.900	1.001 (0.990-1.011)
LDL	0.002	0.004	0.179	0.672	1.002 (0.994-1.010)
Second trimester					
TC	-0.037	0.115	0.105	0.746	0.963 (0.769-1.207)
TG	0.006	0.005	1.591	0.207	1.006 (0.997-1.015)
HDL	0.000	0.009	0.007	0.931	0.999 (0.982-1.017)
LDL	0.065	0.153	0.179	0.672	1.067 (0.791-1.440)
Third trimester					
TC	0.122	0.097	1.565	0.211	1.129 (0.933-1.366)
TG	0.024	0.032	0.569	0.451	1.024 (0.963-1.090)
HDL	-0.001	0.007	0.024	0.877	0.999 (0.986-1.012)
LDL	-0.333	0.123	7.334	0.007	0.717 (0.564-0.912)
Model 2					
First trimester					
TC	-0.008	0.014	0.376	0.540	0.992 (0.965-1.019)
TG	-0.007	0.013	0.234	0.628	0.994 (0.968-1.020)
HDL	0.001	0.005	0.020	0.888	1.001 (0.990-1.011)
LDL	0.003	0.004	0.679	0.410	1.003 (0.995-1.011)
Second trimester					
TC	-0.023	0.116	0.038	0.845	0.977 (0.778-1.228)
TG	0.009	0.005	3.239	0.072	1.009 (0.999-1.018)
HDL	0.000	0.009	0.010	0.919	0.999 (0.982-1.017)
LDL	0.053	0.156	0.114	0.735	1.054 (0.777-1.430)
Third trimester					
TC	0.090	0.097	0.867	0.352	1.094 (0.905-1.322)
TG	0.017	0.021	0.689	0.406	1.017 (0.977-1.059)
HDL	0.000	0.007	0.018	0.892	0.999 (0.986-1.012)
LDL	-0.243	0.124	3.873	0.049	0.784 (0.615-0.999)
Age	-0.019	0.017	1.256	0.262	0.981 (0.948-1.015)
BMI before pregnancy	0.040	0.023	3.029	0.082	1.041 (0.995-1.089)
Weight gain during pregnancy	0.029	0.015	3.892	0.049	1.029 (1.000-1.059)
BMI before pregnancy	-0.342	0.063	29.674	0.000	0.710 (0.628-0.803)
Birthing methods			4.990	0.082	
Natural labor	-0.509	0.235	4.686	0.030	0.601 (0.379-0.953)
Caesarean section	-0.322	0.236	1.862	0.172	0.725 (0.457-1.151)
Newborn weight	0.000	0.000	7.492	0.006	1.000 (1.000-1.001)

Note: TC: total cholesterol; TG: triglyceride; HDL-C: high density lipoprotein cholesterol; LDL-C: low density lipoprotein cholesterol; BMI: body mass index.

pregnancies, characterized by increased TG and decreased HDL-C levels. These lipid changes were linked to newborn birth weight, and the combination of abnormal glucose and lipid metabolism was associated with an increased incidence of macrosomia. Additionally, You et al. [27] found that TG levels in patients with adverse pregnancy outcomes were higher than

Table 7. Correlation between blood lipid indices and the number of complications

Item		First trimester				Second trimester				Third trimester			
		TC	TG	HDL-C	LDL-C	TC	TG	HDL-C	LDL-C	TC	TG	HDL-C	LDL-C
Complications number	r	0.099	0.146	-0.106	0.137	0.027	0.152	-0.102	0.009	0.031	0.191	-0.064	-0.056
	P	0.002	0.000	0.001	< 0.001	0.401	< 0.001	0.001	0.785	0.330	< 0.001	0.043	0.076

Note: TC: total cholesterol; TG: triglyceride; HDL-C: high density lipoprotein cholesterol; LDL-C: low density lipoprotein cholesterol.

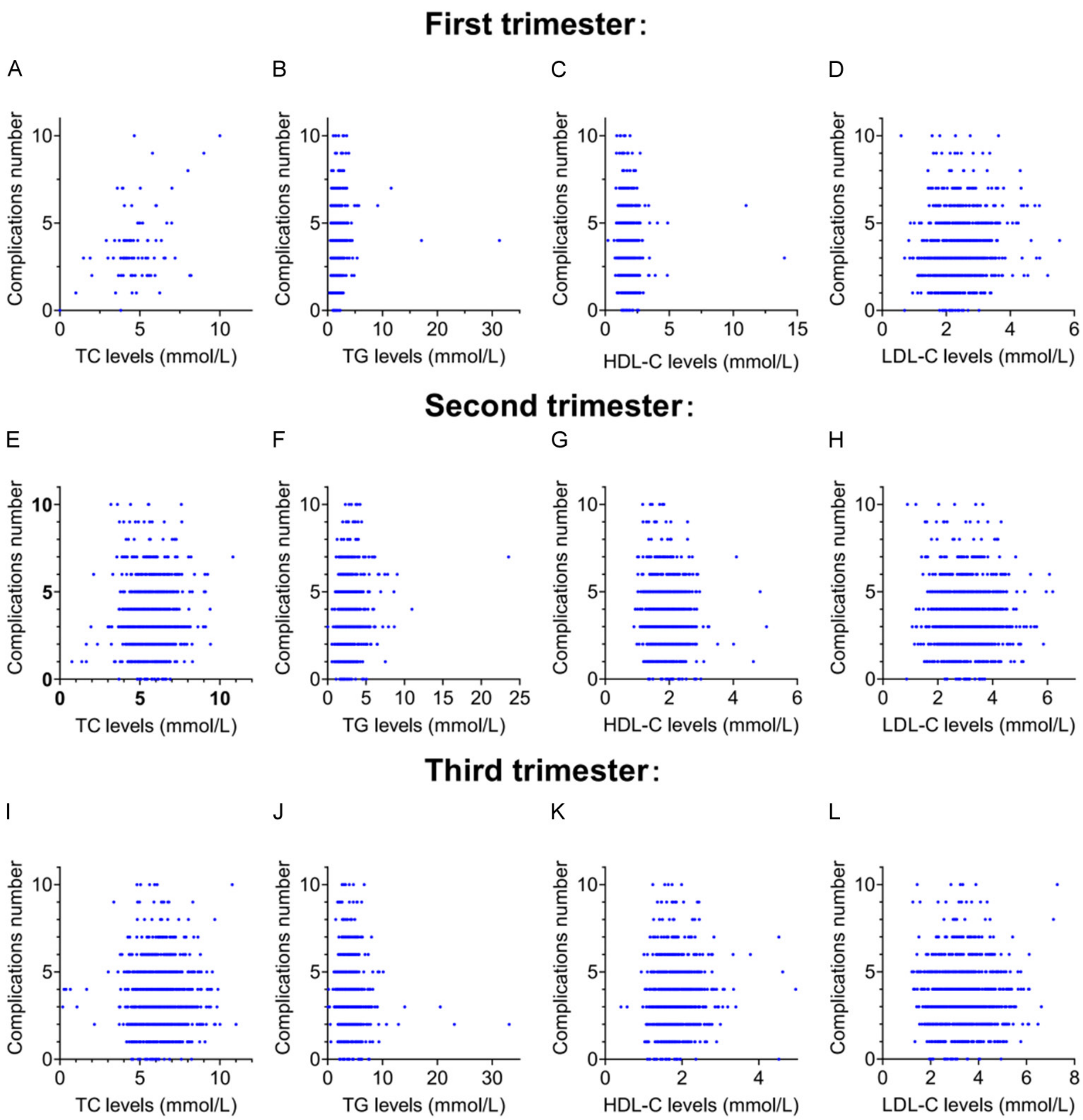

Figure 1. Correlation between blood lipid indices and the number of complications. Note: TC, TG, HDL-C and LDL-C in the first, second and third trimesters of pregnancy had no significant correlation with the number of complications. A: TC levels during early pregnancy on an x-axis ranging from 0 to 10 mmol/L, with most data points centered around 5 mmol/L. B: TG levels during early pregnancy with an x-axis from 0 to 30 mmol/L, primarily clustering near 0 mmol/L. C, D: HDL-C and LDL-C levels in early pregnancy with respective x-axis ranges of 0 to 15 mmol/L and 0 to 6 mmol/L, where points are mostly around 0 mmol/L and 2 mmol/L, respectively. E: In the second trimester, TC levels are shown with an x-axis from 0 to 10 mmol/L and scatter points mainly distributed near 5 mmol/L. F: TG levels with a scale of 0 to 25 mmol/L and data points around 2.5 mmol/L. G, H: The x-axis represents HDL-C and LDL-C levels during the second trimester, with a scale range from 0 to 6 mmol/L. In subfigure G (describing HDL-C levels), the scatter points are primarily clustered around 2 mmol/L, whereas in subfigure H (describing LDL-C levels),

they are concentrated between 2 and 4 mmol/L. I: In the third trimester, TC levels on a scale of 0 to 10 mmol/L with points mainly distributed near 6 mmol/L. J: In the third trimester, TG levels with an x-axis of 0 to 30 mmol/L. K, L: Subfigure K describes HDL-C levels, and L describes LDL-C levels with scales of 0 to 4 mmol/L and 0 to 8 mmol/L, with scatter points around 2 mmol/L and 4 mmol/L, respectively. TC: total cholesterol; TG: triglyceride; HDL-C: high density lipoprotein cholesterol; LDL-C: low density lipoprotein cholesterol.

those in patients with normal outcomes, suggesting a correlation of high TG to adverse pregnancy outcomes. Eppel et al. [28] also observed that women with hypertriglyceridemia had higher average blood glucose levels in the first and second trimesters, and that elevated triglycerides in the first trimester increased the risk of gestational diabetes.

Therefore, the actual data and correlation analysis results from this study are not entirely consistent with previous findings, highlighting the need for further, more reliable research data to clarify these relationships.

Advantages and limitations

This study explored the correlation between lipid levels at different stages of pregnancy and pregnancy complications as well as outcomes, finding that dyslipidemia was not related to pregnancy complications and pregnancy outcomes. However, this study was a single-center study which may have led to data bias. In addition, this was a retrospective study, so it was hard to control a lot of complicating factors. Therefore, the conclusion of this study should be further verified by multi-center controlled study with large sample size in the future.

Conclusion

The lipid levels in pregnant women in the second and third trimesters of pregnancy increased, and there was no correlation between elevated lipid levels and pregnancy complications or adverse pregnancy outcomes.

Acknowledgements

This study was supported by grant from Ruixin cultivation plan of Hunan maternal and Child Health Hospital 2021RX09.

Disclosure of conflict of interest

None.

Abbreviations

TC, Total cholesterol; TG, Triglyceride; HDL-C, High density lipoprotein cholesterol; LDL-C, Low density lipoprotein cholesterol; GDM, Gestational diabetes mellitus; OGTT, Oral glucose tolerance test; ANOVA, Analysis of variance; BMI, Body mass index; SE, Standard error; OR, Odds ratio; CI, Confidence interval.

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