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Article

Maternal Obesity and Neonatal Cardiac Remodeling Among Cesarean Deliveries: The Predictive Role of Maternal Lipid Profiles and Pre-Pregnancy BMI Based on Echocardiographic Assessment

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Abstract

Aims/Background: Maternal obesity has been recognized as a critical factor influencing fetal cardiovascular development. Metabolic disturbances during pregnancy potentially affect neonatal cardiac structure and function. Cesarean section, which is more frequently performed among obese pregnant women, may further influence neonatal adaptation after birth. This study aimed to investigate the association between maternal pre-pregnancy obesity and neonatal left ventricular (LV) structure and function in a cohort of cesarean deliveries and to analyze the associations between maternal gestational weight, lipid profile, and neonatal cardiac function parameters. **Methods**: This retrospective cohort study was conducted at Yongkang Women and Children's Health Hospital between January 2021 and August 2024. Initially, 231 pregnant women were screened, of whom 161 mother-infant pairs met the predetermined inclusion criteria. Pregnant women undergoing cesarean delivery were assigned to a non-obese group and an obese group. Maternal demographic data, lipid profiles during pregnancy (total cholesterol [TC], triglycerides [TG], low-density lipoprotein cholesterol [LDL-C], and high-density lipoprotein cholesterol [HDL-C]), and neonatal echocardiographic parameters (interventricular septal thickness in diastole [IVSd], left ventricular posterior wall thickness in diastole [LVPWd], IVSd/LVPWd ratio, left ventricular ejection fraction [LVEF], mitral annular plane systolic excursion [MAPSE], tricuspid annular plane systolic excursion [TAPSE], right ventricular fractional area change [RVFAC], left ventricular deceleration time [LV DCT], Tei index, and E/e') were collected. Correlation and multivariate regression analyses were conducted to evaluate the effects of maternal obesity and lipid levels on neonatal cardiac function. **Results**: Pre-pregnancy body mass index (BMI) and neonatal birth weight were significantly higher in the obese group compared to the non-obese group ($p < 0.05$). Neonates in the obese group had significantly increased IVSd, LVPWd, and LV DCT, while IVSd/LVPWd ratio and TAPSE were significantly lower than those in the non-obese group ($p < 0.05$). IVSd/LVPWd ratio was positively correlated with neonatal birth weight and maternal TG levels in late pregnancy. Furthermore, TAPSE showed a positive correlation with maternal HDL-C levels and a negative correlation with maternal pre-pregnancy TG and BMI, while LV DCT demonstrated a positive correlation with neonatal birth weight, pre-pregnancy BMI, and maternal TC, TG, and LDL-C levels in late pregnancy. Multivariate regression analysis identified neonatal birth weight, pre-pregnancy BMI, and maternal TC and LDL-C levels as independent predictors of LV DCT ($p < 0.05$). **Conclusion**: Maternal pre-pregnancy BMI and lipid levels during pregnancy significantly affect neonatal LV structure and function. These findings suggest that maternal obesity and metabolic disturbances may adversely influence neonatal cardiac development.

Keywords: obesity; newborn; heart ventricles; ventricular function; echocardiography

1. Introduction

With the ongoing changes in socioeconomic conditions and lifestyle, obesity has emerged as a common and serious global public health concern [1]. During pregnancy, maternal obesity is consistently linked to a higher likelihood of complications, including gestational diabetes, hypertension, and postpartum infections [2,3], and it may also affect neonatal outcomes [4]. Cesarean section (C-section) delivery is more common in women with obesity [5]; however, the potential implications of this delivery mode for neonatal cardiac structure and function remain underexplored.

In this context, C-section offers a clinically relevant and relatively homogeneous delivery mode for studying obese pregnancies. Compared with vaginal birth, C-section avoids labor-related hemodynamic fluctuations, intermittent hypoxia, and stress hormone increase, all of which can independently influence neonatal cardiovascular function after birth [6]. Limiting the study population to C-section deliveries, therefore, helps reduce confounding effects from delivery mode and allows a clearer assessment of how obesity-associated maternal metabolic disturbances may link to neonatal cardiac outcomes.

The neonatal age is a critical period for cardiac growth and functional maturation. Metabolic dysregulation associated with maternal obesity may interfere with normal cardiac development, potentially resulting in structural abnormalities and functional impairments [7]. A previous study has shown that neonates born to mothers with obesity tend to have a higher prevalence of myocardial hypertrophy [8].

Among cardiac parameters, left ventricular (LV) structure and function are key indicators of neonatal cardiovascular health [9,10]. Although most previous studies have often investigated single parameters, such as the Tei index or myocardial strain, to assess cardiac function in fetuses or preterm infants [11–13], comprehensive evaluations of LV diastolic function in term neonates remain limited. Particularly, LV deceleration time (LV DCT), a load-sensitive parameter that indicates LV filling pressure, has rarely been included in systematic assessments.

Therefore, assessing neonatal LV structure and function in infants delivered by C-section to mothers with obesity has both clinical and public health significance. In this study, neonatal echocardiography was performed to evaluate cardiac structural and functional changes, aiming to inform obstetric decision-making and enhance early neonatal cardiac monitoring strategies.

2. Methods

2.1 Baseline Characteristics: Recruitment of the Study Participants and Study Design

This retrospective cohort study included parturients and their neonates who delivered at Yongkang Women and Children's Health Hospital between January 2021 and August 2024. In total, 231 pregnant women were screened (initial cohort, n = 231). After applying the predefined inclusion criteria, 217 women were found eligible (inclusion cohort, n = 217). A further 56 participants were excluded based on the exclusion criteria (exclusion cohort, n = 56), yielding 161 mother-infant pairs for final analysis (final included cohort, n = 161; Fig. 1). Study participants were grouped based on pre-pregnancy body mass index (BMI). Among them, 83 mother-infant pairs were assigned to the non-obese group, and 78 to the obese group. Obesity was defined as a pre-pregnancy BMI $\geq$28 kg/m^2 [14]. All included participants were delivered by cesarean section. The indications for cesarean delivery were obtained from medical records and primarily included elective cesarean section, previous cesarean delivery, maternal request, and suspected macrosomia.

Inclusion criteria were as follows: (1) age 18–35 years; (2) normal communication and cognitive abilities; and (3) singleton, cephalic presentation deliveries at 38–42 weeks of gestation. Exclusion criteria included: (1) multiple gestation (twins or higher-order pregnancies); (2) psychiatric disorders or inability to cooperate with clinical assessment; (3) incomplete clinical data or loss to follow-up; (4) maternal congenital or acquired heart disease, chronic kidney disease, or autoimmune disorders; (5) recent use of medications known to affect lipid metabolism, glucose metabolism, or maternal metabolic status; (6) neonates with congenital heart disease, major structural malformations, or significant arrhythmias; and (7) neonates with intrauterine infection, birth asphyxia, or requiring advanced resuscitation at delivery.

2.2 Maternal Lipid Profile Assessment

Maternal blood lipid profiles were assessed during the third trimester of pregnancy. Following an overnight fast of at least 8 hours, venous blood samples were collected in the morning. Serum concentrations of the following lipid parameters were measured: total cholesterol (TC), triglycerides (TG), low-density lipoprotein cholesterol (LDL-C), and high-density lipoprotein cholesterol (HDL-C).

2.3 Echocardiographic Assessment

All neonates received a comprehensive echocardiographic examination on the first day after birth while naturally asleep. Given the retrospective study design, echocardiographic measurements were extracted from the hospital's routine clinical echocardiography database. All examinations were performed according to standardized neonatal echocardiographic protocols used at Yongkang Women and Children's Health Hospital.

Parameters assessed during echocardiography included: (1) M-mode imaging in the parasternal long-axis view to measure interventricular septal thickness in diastole (IVSd) and left ventricular posterior wall thickness in diastole (LVPWd). All measurements were averaged over three consecutive cardiac cycles. (2) Left ventricular ejection fraction (LVEF) was calculated using Simpson's method from apical four-chamber and apical two-chamber views. (3) Mitral annular plane systolic excursion (MAPSE) and tricuspid annular plane systolic excursion (TAPSE) were measured to assess longitudinal myocardial motion. (4) Right ventricular fractional area change (RVFAC) was calculated from the difference between right ventricular (RV) end-diastolic and end-systolic areas. (5) Pulsed-wave Doppler imaging was used to measure peak early diastolic flow velocity (E) and deceleration time (DCT) of ventricular filling. (6) Early diastolic mitral annular velocities (e′), reflecting myocardial relaxation, were obtained using tissue Doppler imaging at the lateral annuli of the mitral valves in the apical four-chamber view.

The Tei index and E/e' ratio were assessed using pulsed-wave Doppler imaging in parasternal or apical four-chamber views for both right and left ventricles, reflecting measures of overall myocardial performance and estimated ventricular filling pressure, respectively. All echocardiographic measurements were recorded for subsequent analysis.

2.4 Statistical Analysis

Statistical analysis was conducted using SPSS version 26.0 (IBM Corp., Armonk, NY, USA) and R version 4.3.2 (R Foundation for Statistical Computing, Vienna, Austria). Normality of continuous variables was evaluated with the Shapiro–Wilk test. Normally distributed variables were reported as mean $\pm$ standard deviation (mean $\pm$ SD) and between-group comparisons were performed using an independent-samples *t* test. Non-normally distributed vari-

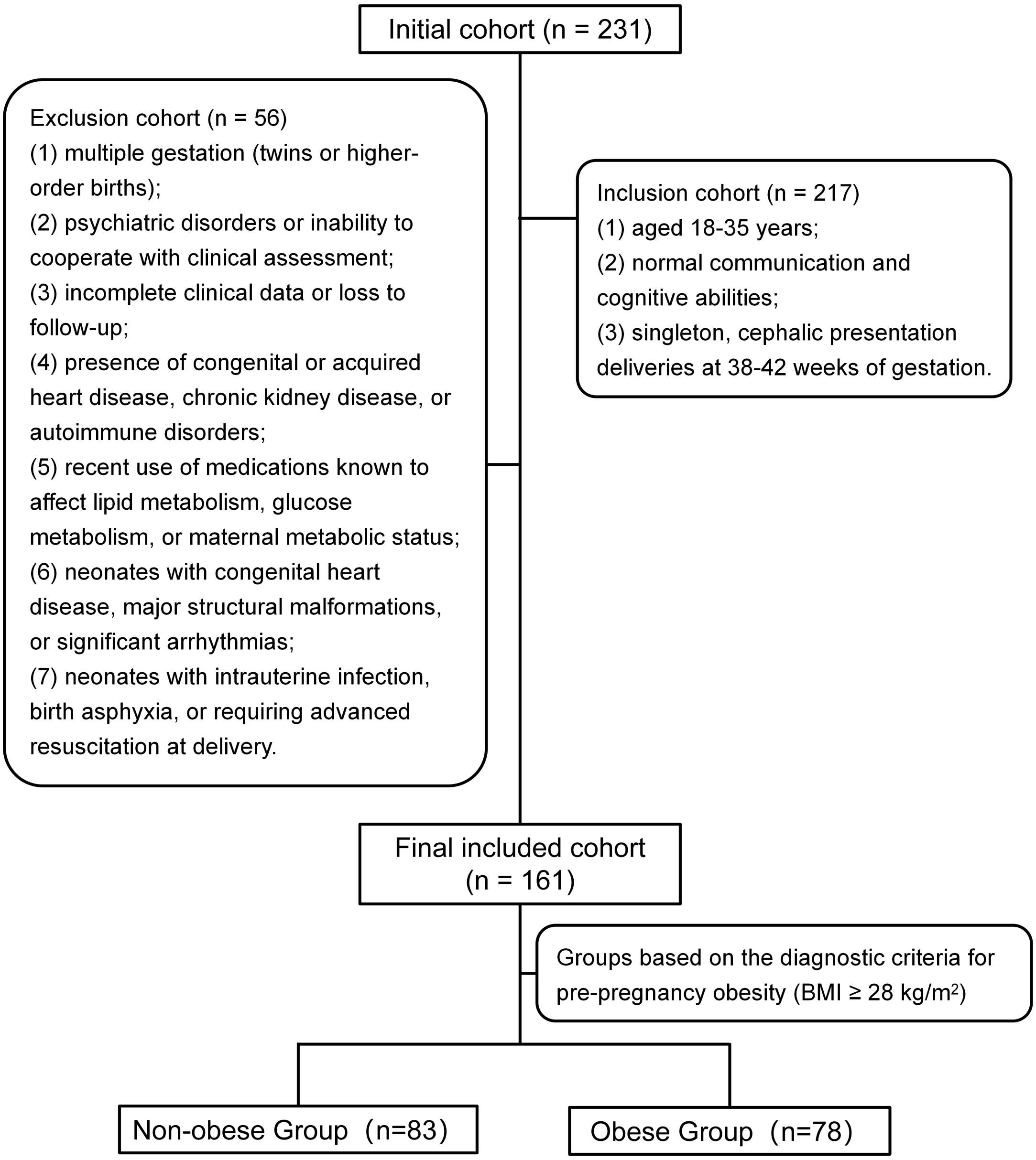

Fig. 1. A flowchart of patient selection and study design. BMI, body mass index.

ables were presented as median and interquartile range [M (IQR)] and analyzed using the Mann–Whitney U test. Categorical variables were presented as frequencies and percentages (%) and were compared using the chi-square test.

Associations between neonatal echocardiographic parameters and clinical or biochemical variables were assessed using Spearman's rank correlation test. To identify independent predictors of neonatal LV DCT, a multivariable linear regression model was established with LV DCT specified as the dependent variable and clinically relevant parameters as independent variables. Before model construction, multicollinearity among covariates was evaluated using variance inflation factors (VIFs) and tolerance statistics; VIF values <5 and tolerance values >0.20 were considered indicative of acceptable collinearity. A two-sided p-value < 0.05 was considered statistically significant.

3. Results

3.1 Comparison of Baseline Clinical Characteristics Between the Two Groups

Baseline clinical features for the non-obese and obese groups are presented in Table 1. Pre-pregnancy BMI was substantially higher in the obese group than in the non-obese group ($p < 0.05$). The obese group also had higher rates of gestational hypertension and gestational diabetes. Furthermore, neonates born to mothers with obesity had significantly greater birth weights than those in the non-obese group ($p < 0.05$), and the gestational age at delivery was significantly shorter in the obese group ($p < 0.05$). However, no considerable between-group differences were observed for maternal age, the proportion of regular prenatal check-ups, parity, gravidity, indications for cesarean

Table 1. Comparison of general characteristics between the non-obese and obese groups.

Variable	Non-obese group (n = 83)	Obese group (n = 78)	t/Z/χ^2	p-value
Age (years)	28.04 ± 4.13	27.54 ± 4.52	0.730	0.466
BMI (kg/m^2)	22.72 (20.86, 26.23)	31.17 (28.71, 34.00)	10.950	<0.001*
Parity	1 (1, 2)	1.5 (1, 2)	0.231	0.818
Gravidity	1 (1, 2)	1 (1, 2)	0.041	0.967
Indications for cesarean section			0.983	0.805
Elective cesarean section	36 (43.37%)	31 (39.74%)		
Previous cesarean delivery	20 (24.10%)	16 (20.51%)		
Maternal request	24 (28.92%)	27 (34.62%)		
Suspected macrosomia	3 (3.61%)	4 (5.13%)		
Regular prenatal check-ups (%)	76 (91.57%)	73 (93.59%)	0.239	0.625
Hypertension during pregnancy (%)	9 (10.84%)	18 (23.08%)	4.312	0.038*
Gestational diabetes (%)	8 (9.64%)	17 (21.79%)	4.530	0.033*
Gestational weeks at delivery (week)	40 (39, 40)	39 (38, 39)	–5.288	<0.001*
Birth weight (g)	3345.25 ± 338.62	3528.18 ± 411.57	3.069	0.003*
Neonatal gender (%)			1.382	0.240
Boy	46 (55.42%)	36 (46.15%)		
Girl	37 (44.58%)	42 (53.85%)		
Apgar score at 5 minutes	9 (8, 10)	9 (7, 10)	1.131	0.258

*$p < 0.05$ was considered statistically significant.

Table 2. Comparison of maternal lipid profiles in late pregnancy between the non-obese and obese groups.

Variable	Non-obese group (n = 83)	Obese group (n = 78)	t/Z	p-value
TC (mmol/L)	5.78 ± 0.51	6.12 ± 0.41	–4.750	<0.001*
TG (mmol/L)	2.75 ± 0.38	3.01 ± 0.51	–3.654	<0.001*
LDL-C (mmol/L)	3.06 (2.57, 3.72)	3.43 (3.11, 3.84)	3.222	0.001*
HDL-C (mmol/L)	1.91 ± 0.18	1.83 ± 0.18	2.628	0.009*

TC, total cholesterol; TG, triglycerides; LDL-C, low-density lipoprotein cholesterol; HDL-C, high-density lipoprotein cholesterol. *$p < 0.05$ was considered statistically significant.

section, neonatal gender, or Apgar scores at 5 minutes ($p > 0.05$).

3.2 Comparison of Maternal Lipid Profiles Between the Two Groups

As summarized in Table 2, maternal serum levels of TC, TG, and LDL-C in late pregnancy were significantly higher in the obese group than in the non-obese group ($p < 0.05$). In contrast, HDL-C levels were substantially lower in the obese group ($p < 0.05$).

3.3 Comparison of Neonatal Echocardiographic Parameters Between Obese and Non-Obese Groups

Neonatal echocardiographic findings are summarized in Table 3. Compared with the non-obese group, neonates born to women with obesity had significantly greater IVSd, LVPWd, and LV DCT ($p < 0.05$). In contrast, the IVSd/LVPWd ratio and TAPSE were significantly lower in the obese group ($p < 0.05$). However, no significant differences were observed between the two groups in LVEF, MAPSE, RVFAC, Tei index, or E/e' ratio ($p > 0.05$).

3.4 Correlation Analysis of Echocardiographic Parameters With Clinical and Lipid Variables

To elucidate how maternal metabolic status influences neonatal cardiac parameters, we performed correlations within the obese group between maternal lipid levels in late pregnancy (TC, TG, LDL-C, HDL-C), pre-pregnancy BMI, neonatal birth weight, and key echocardiographic parameters (IVSd/LVPWd, TAPSE, and LV DCT).

As summarized in Table 4, the IVSd/LVPWd ratio was positively associated with neonatal birth weight and maternal TG levels in late pregnancy ($p < 0.05$). TAPSE was positively correlated with maternal HDL-C levels in late pregnancy ($p < 0.05$) but showed a negative correlation with pre-pregnancy BMI and maternal TG levels ($p < 0.05$). LV DCT was positively correlated with neonatal birth weight, pre-pregnancy BMI, and maternal TC, TG and LDL-C levels in late pregnancy ($p < 0.05$).

3.5 Multiple Linear Regression Analysis of Factors Influencing Neonatal LV DCT

Because LV DCT was correlated with multiple clinical and biochemical variables (neonatal birth weight, pre-pregnancy BMI, TC, LDL-C, and TG), a multivariable lin-

Table 3. Comparison of neonatal cardiac ultrasound parameters between the non-obese and obese groups.

Variable	Non-obese group (n = 83)	Obese group (n = 78)	*t*/Z	*p*-value
IVSd (mm)	2.92 (2.71, 3.25)	3.11 (2.74, 3.62)	2.009	0.044*
LVPWd (mm)	2.62 (2.42, 2.91)	2.89 (2.71, 3.09)	4.862	<0.001*
IVSd/LVPWd	1.12 (1.11, 1.14)	1.08 (1.00, 1.17)	–2.090	0.037*
LVEF (%)	71 (66, 73)	70 (66, 74)	–0.535	0.592
MAPSE (mm)	7.97 ± 1.04	7.87 ± 0.79	0.706	0.481
TAPSE (mm)	11.15 (10.06, 12.10)	10.25 (9.31, 11.35)	–3.701	<0.001*
RVFAC (%)	46 (45, 47)	46 (45, 47)	–0.377	0.706
LV DCT (ms)	79.40 ± 4.86	81.22 ± 5.05	–2.333	0.021*
Tei	0.38 ± 0.03	0.39 ± 0.03	–1.458	0.147
E/e'	7.86 ± 0.89	7.67 ± 0.66	1.548	0.124

IVSd, interventricular septal thickness in diastole; LVPWd, left ventricular posterior wall thickness in diastole; LVEF, left ventricular ejection fraction; MAPSE, mitral annular plane systolic excursion; TAPSE, tricuspid annular plane systolic excursion; RVFAC, right ventricular fractional area change; LV DCT, left ventricular deceleration time; E/e′, the ratio of early diastolic transmitral flow velocity (E) to early diastolic mitral annular velocity (e′). *$p < 0.05$ was considered statistically significant.

Table 4. Correlations between cardiac ultrasound parameters and pre-pregnancy BMI, birth weight, and maternal lipid profile.

	IVSd/LVPWd		TAPSE		LV DCT	
	r	*p*-value	r	*p*-value	r	*p*-value
Birth weight	0.430	<0.001*	0.041	0.607	0.530	<0.001*
BMI	–0.039	0.624	–0.269	0.001*	0.573	<0.001*
TC	0.043	0.585	–0.084	0.290	0.586	<0.001*
TG	0.376	<0.001*	–0.171	0.030*	0.249	0.001*
LDL-C	0.140	0.077	–0.142	0.072	0.469	<0.001*
HDL-C	0.021	0.793	0.550	<0.001*	0.092	0.247

*$p < 0.05$ was considered statistically significant.

Table 5. Multiple linear regression analysis of factors influencing neonatal LV DCT.

	Unstandardized coefficients		Standardized coefficients	*t*	*p*-value	VIF	Tolerance
	B	SE	Beta				
Birth weight	0.004	0.001	0.300	4.912	<0.001*	1.338	0.747
BMI	0.263	0.075	0.270	3.523	0.001*	2.111	0.474
TC	3.224	0.667	0.317	4.831	<0.001*	1.541	0.649
LDL-C	1.196	0.507	0.154	2.359	0.020*	1.520	0.658
TG	–0.219	0.620	–0.020	–0.354	0.724	1.202	0.832
Age	0.007	0.064	0.006	0.112	0.911	1.069	0.935
Hypertension during pregnancy	–0.084	0.731	–0.006	–0.115	0.909	1.067	0.938
Gestational weeks at delivery	0.141	0.323	0.025	0.437	0.663	1.184	0.844
Gestational diabetes	–1.104	0.752	–0.080	–1.468	0.144	1.061	0.942

VIF, variance inflation factor; SE, standard error. *$p < 0.05$ was considered statistically significant.

ear regression model was used to identify variables independently associated with LV DCT.

LV DCT was set as the dependent variable, and neonatal birth weight, pre-pregnancy BMI, and maternal TC, LDL-C, and TG levels in late pregnancy as independent variables. To control for potential confounding factors, the study included clinical variables age, gestational hypertension, gestational age at delivery, and gestational diabetes.

Before model construction, multicollinearity among these variables was assessed using VIF and Tolerance statistics, and all variables met the acceptable thresholds (VIF <5 and Tolerance >0.2; Table 5), indicating no significant multicollinearity.

As shown in Table 5, neonatal birth weight, pre-pregnancy BMI, maternal TC, and LDL-C levels remained statistically significant independent predictors of LV DCT (*t*: 4.912, 3.523, 4.831, and 2.359, respectively; all $p < 0.05$). The model demonstrated good explanatory performance (F = 23.027, $p < 0.001$), with an R^2 of 0.578 and an adjusted R^2 of 0.553.

4. Discussion

In this study, we investigated how maternal metabolic status, particularly lipid profiles and pre-pregnancy BMI, relates to neonatal cardiac structure and function among cesarean deliveries. With the global rise in obesity rates, obesity during pregnancy has become a significant public health concern affecting both maternal and neonatal health [15]. Maternal obesity is associated with a higher likelihood of pregnancy complications, particularly gestational hypertension and diabetes, and it may also adversely affect fetal cardiovascular development [16]. Growing evidence suggests that obesity in pregnant women can influence the cardiovascular development of the fetus as early as the intrauterine period and may persist postnatally [17]. Consistent with this context, we observed that women with obesity had higher incidences of gestational hypertension and diabetes. Notably, their neonates showed significant differences in cardiac parameters, suggesting early changes in cardiac structure and function.

Although gestational hypertension and gestational diabetes differed between groups at baseline, neither remained independently associated with neonatal cardiac indices after multivariable adjustment. One possible explanation is that their effects are largely mediated through maternal adiposity and the broader metabolic disturbances, particularly dyslipidemia. Once pre-pregnancy BMI and lipid profiles were included in the model, the apparent "standalone" effects of these pregnancy complications were likely decreased because they share overlapping mechanisms with obesity-related metabolic dysfunctions.

Maternal lipid metabolism, especially in late pregnancy, plays a critical role in fetal growth and organ development. In our cohort, levels of TC, TG, and LDL-C were significantly higher in obese pregnant women, along with lower HDL-C levels. This pattern aligns with previous studies indicating that maternal hyperlipidemia during pregnancy is a physiological adaptation to meet the increasing energy demands of the fetus; however, this rise can be exacerbated in obese women and may shift from adaptive to potentially harmful, thereby increasing the likelihood of adverse fetal cardiovascular outcomes [18,19].

Neonates born to obese mothers exhibited increased interventricular septal and left ventricular posterior wall thickness (IVSd, LVPWd) along with a longer LV DCT. These results suggest impaired myocardial relaxation and early signs of diastolic dysfunction. Meanwhile, the IVSd/LVPWd ratio and tricuspid annular plane systolic excursion (TAPSE) were significantly reduced, indicating a mild shift in ventricular wall balance and a subtle reduction in right ventricular systolic function. Overall, these changes are consistent with the possibility that maternal metabolic dysfunctions contribute to in-utero cardiac remodeling.

Previous studies indicate that maternal obesity is correlated with changes in fetal cardiac geometry, including a thicker ventricular wall and reduced diastolic compliance, detectable as early as the second trimester [20,21]. Animal model-based experimental studies also support a causal link: exposure to a maternal high-fat diet has been reported to promote fetal myocardial hypertrophy and fibrosis, and dysregulate expression of genes involved in cardiac metabolism and extracellular matrix remodeling [22]. Human echocardiographic studies of neonates and infants born to mothers with obesity similarly demonstrate increased left ventricular mass index and subtle reduction in both systolic and diastolic function, even when no structural congenital heart disease is present [23,24]. These findings support the concept of fetal cardiac programming, in which the intrauterine environment, particularly maternal metabolic status, affects cardiovascular development and may influence long-term disease risk. Consistent with this framework, our findings extend the existing evidence by indicating functional changes involving both the left and right ventricles in term neonates of mothers with obesity. These observations highlight the significance of early cardiac assessment and follow-up in this high-risk cohort.

Correlation analysis highlighted significant associations between neonatal echocardiographic parameters and maternal metabolic status. Specifically, LV DCT showed positive correlations with neonatal birth weight, pre-pregnancy BMI, and maternal late-pregnancy levels of TC, TG and LDL-C. Based on these findings, we conducted multivariable linear regression to identify independent predictors of LV DCT. The model identified that neonatal birth weight, pre-pregnancy BMI, maternal TC, and LDL-C were all significant predictors.

Importantly, these echocardiographic changes were observed in a cohort of neonates delivered by cesarean section. This pattern matters because in the absence of labor-related stressors and hemodynamic fluctuations, the neonatal cardiovascular system may rely more directly on intrauterine myocardial programming. Maternal dyslipidemia, particularly elevated TC and LDL-C levels, may impair myocardial relaxation by altering placental lipid transfer, promoting oxidative stress and low-grade inflammation, and disrupting fetal myocardial energy metabolism, calcium handling, and extracellular matrix composition. Consequently, diastolic dysfunctions may become more apparent. Evidence by a prolonged LV DCT. In this context, the observed diastolic abnormalities may reflect cumulative prenatal metabolic exposure. This could explain why LV DCT emerged as a sensitive functional marker in our cohort, while global systolic indices, such as LVEF remained largely unchanged.

Recent evidence has increasingly focused on identifying cardiovascular risk in neonates using maternal and perinatal indicators. For instance, maternal hypercholesterolemia has been associated with increased fetal aortic intima-media thickness, an established early marker of vascular dysfunction [25]. Other studies have demonstrated an association between maternal dyslipidemia and alterations in fetal cardiac output and ventricular dimensions, even in otherwise uncomplicated pregnancies [17,26]. Overall, these findings suggest that the intrauterine metabolic environment may shape neonatal cardiovascular structure and function, effects that may extend beyond birth.

Consistent with this growing body of evidence, our study demonstrated that maternal pre-pregnancy BMI and late-pregnancy lipid profiles were significantly associated with neonatal left ventricular structural and functional parameters, particularly LV diastolic function as reflected by LV DCT. While prior studies primarily focused on systolic indices or gross structural measurements, we incorporated LV DCT as a more sensitive marker of early diastolic remodeling. Using correlation analyses followed by multivariate linear regression, we identified that neonatal birth weight, maternal pre-pregnancy BMI, and maternal TC and LDL-C levels were independent determinants of LV DCT. These results underscore the quantitative relationship between maternal metabolic disturbances and subtle alterations in neonatal cardiac function present at birth.

Despite its strengths, this study has certain limitations that should be acknowledged. First, the relatively small sample size may restrict generalizability of the results and reduce statistical power to detect weaker associations. Second, because the analysis was cross-sectional, causal relationships cannot be established. Prospective longitudinal studies with follow-up echocardiography during infancy and childhood are required to determine whether these early findings translate into long-term cardiovascular implications. Third, maternal lipid levels were collected only during the third trimester; we were therefore unable to assess how lipid changes across pregnancy affect neonatal cardiac remodeling, which may influence both exposure timing and cumulative metabolic effects. Fourth, although we adjusted for several key clinical confounders (maternal age, hypertension during pregnancy, gestational diabetes, and gestational age at delivery), other potentially relevant indicators such as maternal blood pressure trajectories and gestational weight gain were not included because of missing or incomplete records in this retrospective cohort. Residual confounding, therefore, remains possible. In addition, echocardiography was performed on the first postnatal day, a period of rapid hemodynamic transition, during which cardiac functional indices may be influenced by transient changes in preload and afterload, which may influence measured parameters. Finally, although the echocardiographic evaluation was comprehensive, it may not fully capture early myocardial metabolic or microstructural alterations. Advanced imaging modalities such as speckle-tracking echocardiography or cardiac magnetic resonance imaging (MRI) could offer a more sensitive assessment of subtle myocardial changes.

5. Conclusion

In conclusion, our results underscore that maternal metabolic health, especially pre-pregnancy lipid homeostasis and body weight, is closely associated with neonatal cardiac structure and function. These findings support the significance of proactive prenatal approaches to enhance maternal metabolic status, which may help reduce early subclinical cardiac alteration in neonates and improve their cardiovascular health.

Key Points

• Maternal pre-pregnancy BMI and lipid profiles during pregnancy are associated with alterations in neonatal left ventricular structure and function.

• Neonates born to mothers with obesity exhibit increased interventricular septal thickness, left ventricular posterior wall thickness, and prolonged LV deceleration time.

• Neonatal birth weight, maternal pre-pregnancy BMI, and maternal TC and LDL-C levels are independent predictors of LV deceleration time.

• Comprehensive echocardiographic assessment combined with maternal metabolic status can help identify neonates at risk for subclinical cardiac dysfunction.

• Optimizing maternal metabolic health before and during pregnancy may mitigate adverse effects on neonatal cardiac development.

Availability of Data and Materials

All data included in this study are available from the corresponding author upon reasonable request.

Author Contributions

QLT: Study concepts and design, methodology, data analysis, statistical analysis, and manuscript drafting. YYL: Data acquisition, data curation, and investigation. YT: Data verification. JXY: Study conception and design, interpretation of data, supervision, and project administration. All authors contributed to revising the manuscript critically for important intellectual content. All authors read and approved the final manuscript. All authors have participated sufficiently in the work and agreed to be accountable for all aspects of the work.

Ethics Approval and Consent to Participate

This study was conducted in accordance with the principles of the Declaration of Helsinki. Ethical approval was obtained from the Ethics Committee of Yongkang Women and Children's Health Hospital (Approval No. YFB2021KS010). Given the retrospective nature of the study and the use of anonymized data, the requirement for informed consent was waived by the ethics committee.

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Conflict of Interest

The authors declare no conflict of interest.

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