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The Association Between Maternal Obesity and Congenital Heart Defects in Fetuses: A Retrospective Cohort Study Using Fetal Echocardiography

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ABSTRACT

Background & Objective: Congenital Heart Disease (CHD) is the most common congenital anomaly and is associated with significant morbidity and mortality. Maternal obesity has been proposed as a potential risk factor for CHD; however, existing evidence remains inconsistent. This study aimed to evaluate the relationship between maternal obesity (BMI≥30) and the occurrence of CHD in fetuses using fetal echocardiography.

Materials & Methods: This retrospective cohort study included 430 pregnant women (215 obese and 215 non-obese) referred to the pediatric cardiology clinic at Hazrat Masoumeh Hospital, Qom, between 2014 and 2023. Demographic and clinical data were extracted from medical records. Fetal echocardiography was performed at 18-20 weeks of gestation. Statistical analyses were conducted using SPSS software, employing t-tests and chi-square tests.

Results: The mean maternal age was 24.58 years in the obese group and 25.18 years in the non-obese group (P=0.133). Cardiac anomalies were detected in 15.3% of fetuses of obese mothers and 17.2% of fetuses of non-obese mothers (P=0.601). Hypertrophic Cardiomyopathy (HCMP) and Tetralogy of Fallot (TOF) were more frequently observed in obese mothers, whereas Ventricular Septal Defect (VSD) and Coarctation of the Aorta (COA) were more frequently observed in non-obese mothers. No statistically significant association was found between maternal obesity and the occurrence of CHD.

Conclusion: Maternal obesity was not significantly associated with the incidence of congenital heart defects or structural cardiac anomalies in fetuses. Given the conflicting findings in previous studies, larger and more comprehensive investigations are needed to clarify this relationship.

Keywords: Congenital Heart Defects (CHD), Obesity, Pregnancy in obesity, Pregnancy, Fetus, Echocardiography

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1. Introduction

Congenital Heart Disease (CHD) is the most prevalent congenital anomaly and encompasses structural or functional abnormalities of the cardiovascular system present at birth **(1,2)**. CHDs account for approximately 0.85%-1.00% of all live births contribute to 30%-40% of infant and early childhood mortality.

The etiology of CHD is multifactorial, involving genetic, environmental, infectious, and pharmacologic factors **(3)**. Despite extensive research, several potential risk factors including maternal obesity remain insufficiently understood. The rising prevalence of overweight and obesity among women of reproductive age in recent years has become a major public health concern. Maternal obesity is associated with numerous pregnancy complications and has been proposed as a

risk factor for congenital anomalies (4,5). Although several studies have examined the association between maternal obesity and CHD, results have been inconsistent. Persson et al., (2019) and Brite et al., (2010) reported a significant positive association, whereas, Rankin et al., and Gharderian et al., found no meaningful relationship (6,7). Obesity is one of the most common conditions encountered in obstetrics and is associated with both maternal and fetal complications, including Gestational Diabetes Mellitus (GDM) and pre-eclampsia (8). According to WHO criteria, obesity is defined as a body mass index (BMI=weight (kg)/[height (m)]²) (9).

In this study, inclusion criteria consisted of singleton pregnancy, maternal age between 20 and 35 years, and BMI≥18.5 kg/m². These criteria ensured a standardized population and minimized confounding factors (10).

Maternal obesity is associated with a 1.7-fold increased risk of Neural Tube Defects (NTDs), and severe obesity is linked to a 3-fold increase in risk (11). Neonates born to mothers with a normal BMI have significantly lower total and relative body fat and higher fat-free mass compared with neonates of overweight or obese mothers. Although preliminary, these findings suggest that the antecedents of future cardiometabolic disease such as cardiovascular disease, diabetes, and obesity may originate early in life (12). The fetuses of obese mothers demonstrate higher percent body fat, greater homeostasis model assessment of insulin resistance, and elevated cord leptin and interleukin-6 levels compared with fetuses of lean women. A strong positive correlation was observed between fetal adiposity and insulin resistance, as well as between maternal pre-pregnancy BMI and fetal insulin resistance, even after adjusting for potential confounders. Cord leptin also showed a significant association with fetal insulin resistance (13). Additionally, obese mothers have shown higher risk of cardiovascular anomalies, septal defects, cleft palate, cleft lip and palate, anorectal atresia, hydrocephaly, and limb reduction defects (14). CHD remains the most common congenital anomaly, encompassing a wide spectrum of defects such as aortic stenosis, coarctation of the aorta, Epstein's anomaly, patent ductus arteriosus, pulmonary stenosis, septal defects (including atrial septal defects and ventricular septal defects), single ventricle defects (including tricuspid atresia, and hypoplastic left heart syndrome), Tetralogy of Fallot, total anomalous pulmonary venous connection, transposition of the great arteries, and truncus arteriosus (15). This study aimed to evaluate maternal obesity as a potential risk factor for the occurrence of congenital heart defects in fetuses. Given the conflicting evidence and the limited number of studies conducted in Iran, further investigation is warranted. Considering the substantial economic, psychological, and healthcare burden associated with CHD, this retrospective cohort study aimed to evaluate fetal cardiac anomalies using fetal echocardiography in obese pregnant women referred to Hazrat Masoumeh Children's Hospital in Qom between 2014 and 2024, and to compare findings with those of normal-weight mothers.

2. Materials and Methods

Study Population

Pregnant women who visited the pediatric cardiology clinic at Hazrat Masoumeh Children's Hospital in Qom between 2014 and 2023 were evaluated. Participants were categorized into two groups based on maternal BMI:

obese mothers: BMI≥30 kg/m² (n=215)

non-obese mothers: BMI<30 kg/m² (n=215).

The sample size was calculated using the findings of Khalil et al., based on the mean prevalence of congenital heart defects in two BMI-based groups, with an alpha of 5% and a beta level of 20% resulting in 215 participants per group.

P1= 0.16

P2= 0.27

a= 0.05

b= 0.2

$$n = \frac{(z_{1-\alpha/2} + z_{1-\beta})^2 (p_1 q_1 + p_2 q_2)}{(p_1 - p_2)^2}$$

Fetal congenital heart defects were identified using fetal echocardiography, and any significant abnormal finding was classified as CHD. Echocardiography was performed at 18-20 weeks of gestation. Maternal BMI was calculated using self-reported height and first-trimester measured weight. Additional demographic and clinical variables including maternal age, parity, and history of diabeteswere obtained through maternal interview and review of medical records. To minimize confounding factors, mothers with mothers with any of the following were excluded:

- History of a previous pregnancy affected by CHD
- Personal or paternal history of CHD
- Use of teratogenic medications
- Epilepsy
- Multifetal pregnancy
- Lupus
- Pre-pregnancy diabetes

• Fetal anomalies detected in first-trimester screening

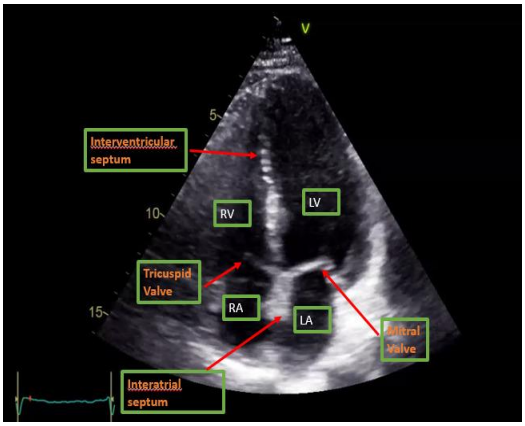
Only singleton pregnancies were included.

Statistical Analysis

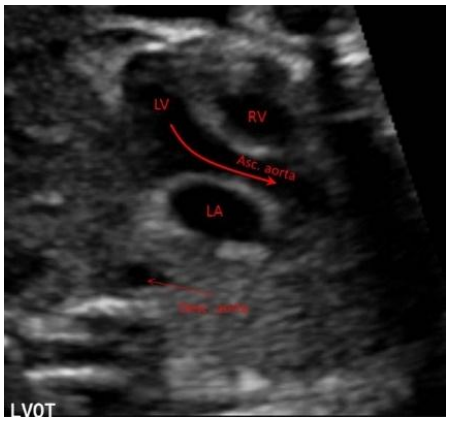
A total of 430 pregnant women (215 obese and 215 non-obese) were analyzed. Statistical analyses were performed using SPSS software. Independent t-tests, chi-square tests, and Fisher's exact tests were applied where appropriate. The two groups were matched as closely as possible for maternal age and parity. Mothers with underlying conditions such as diabetes, epilepsy, lupus, or with a personal or familial history of CHD, were excluded. The frequency of CHD was determined separately in each group on fetal echocardiography findings. Additionally, each specific cardiac anomaly was analyzed individually and compared between groups (Table 1).

Fetal Echocardiography

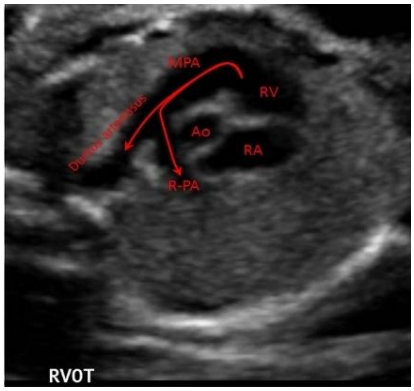
Fetal echocardiography is an ultrasound-based diagnostic tool used to visualize the fetal heart and detect congenital cardiac abnormalities before birth, enabling early planning for postnatal management. The examination included four-chamber view, ventricular outflow tract (LVOT/RVOT) views, three-vessel, and tracheal view. These views allow systematic assessment of cardiac chambers, valves, great vessels, and spatial relationships (Figure 1).

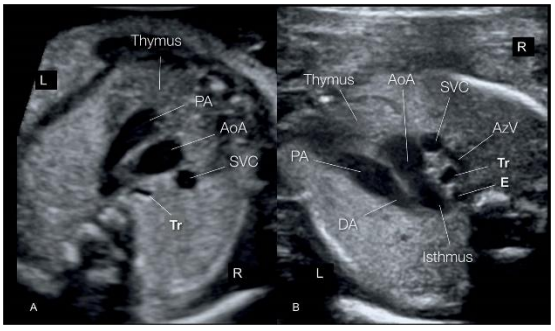


Four-chamber view



Left and right Ventricular Outflow Tract View





Three vessel and tracheal view

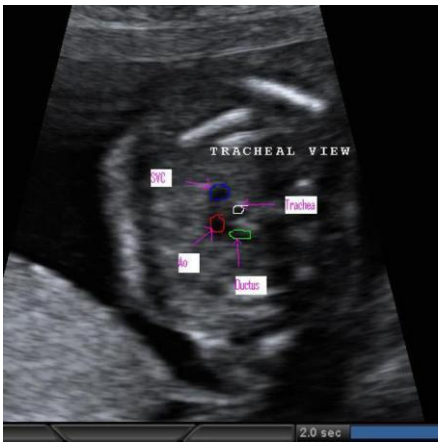


Figure 1. Fetal echocardiography

Table 1. Descriptive analysis of demographic and clinical data of all admitted pregnant women in this study

Variable	Description:
Congenital heart disease (CHD)	A detectable anomaly within fetal echocardiography
obesity	BMI≥30
Age of Mother	Based on the available patients file
Weight of Mother	Kilogram (Kg)
Height of Mother	Meter(m)
Number of Previous Pregnancies	Based on all previous mother's pregnancies

3. Results

The mean maternal age was 24.58 years in the obese group and 25.18 years in the non-obese group (P=0.133).

Parity Distribution

- no previous pregnancy: 27.4% obese vs. 27% non-obese
- One previous pregnancy: 47.9% obese vs. 47.4% non-obese.
- Two previous pregnancies: 18.6% obese vs. 19.5% non-obese
- Three previous pregnancies: 3.7% obese mothers vs. 4.2% non-obese
- Four previous pregnancies: 2.3% obese vs. 1.9% non-obese

In total, in both groups, 27.2% had no previous pregnancy. 47.7% had 1 previous pregnancy, 19.1% had 2 previous pregnancies, 4% had 3 previous pregnancies and 2.1% had 4 previous pregnancies. (Table 2)

No participants in either group had underlying confounding diseases (diabetes, epilepsy, lupus) or a personal/familial history of CHD. Pathological findings on fetal echocardiography were observed in 15.3% of fetuses of obese mothers and 17.2% of fetuses of non-obese mothers (P-value=0.601).

According to Table 3, Structural cardiac defects were slightly more common in obese mothers (8.8%) than in non-obese mothers (7.4%), but this difference was not statistically significant (P=0.597).

Table 2. Comparison of Maternal Age and Parity Distribution Between Obese (BMI ≥ 30) and Non-Obese (BMI < 30) Pregnant Women

		Obesity		P-value
		BMI≥30	BMI<30	
Mother age (mean±SD)		24.5±3.7	25.1± 4.5	0.133*
Frequency Based on the Number of Previous Pregnancies	0	59(27.4)	58(27)	0.994**
	1	103(47.5)	102(47.4)	

2	40(18.6)	42(19.5)
3	8(3.7)	9(4.2)
4	5(2.3)	4(1.9)

* T-Test, **chi-square

Table 3. Association Between Maternal Obesity (BMI≥30) and Congenital Heart Defects (CHD) in Offspring: A Comparative Analysis of Pathological Findings and Heart Anatomical Defects

		Obesity		P value
		BMI≥30	BMI≥30	
CHD	with pathological findings (CHD)	33 (15.3)	37 (17.2)	0.601*
	no pathological findings (healthy)	182 (84.7)	178 (82.8)	
Heart Anatomical Defects	With	19 (8.8)	16 (7.4)	0.597*
	Without	196 (91.2)	199 (92.6)	

*chi-square

Distribution of Specific Cardiac Anomalies

- Certain anomalies were more frequent in obese mothers: Tetralogy of Fallot (TOF): 0.9% in obese mothers vs. 0.5% in non-obese mothers
- Hypertrophic Cardiomyopathy (HCMP): 1.4% in obese mothers vs. 0% in non-obese mothers
- Pulmonary Stenosis (PS): 0.9% in obese mothers vs. 0% in non-obese mothers

Other anomalies were more common in non-obese mothers:

- Ventricular Septal Defect (VSD): 1.4% in non-obese mothers vs. 0.9% in obese mothers
- Large Atrial Septal Defect (ASD II): 1.4% in non-obese mothers vs. 0.9% in obese mothers
- Coarctation of the Aorta (COA): 0.5% in non-obese mothers vs. 0% in obese mothers

Echogenic Focus was detected in 7.4% of non-obese mothers and 5.1% of obese mothers. Overall, 83.7% of all participants (360 mothers) had no pathological findings. These results suggest that maternal obesity may be associated with an increased risk of certain congenital heart defects in newborns Table 4.

Table 4. Frequency and Distribution of Congenital Heart Defects (CHD) and Pathological Findings in Offspring of Obese (BMI ≥ 30) and Non-Obese (BMI < 30) Mothers

Pathology	Obese		Non-obese		Total	
	Frequency	Percent	Frequency	Percent	Frequency	Percent
Atrioventricular Septal Defect (AVSD)	1	0.5%	1	0.5%	2	0.5%
Hypoplastic left heart syndrome (HLHS)	1	0.5%	1	0.5%	2	0.5%
Tetralogy of Fallot (TOF)	2	0.9%	1	0.5%	3	0.7%
Congenital Dilated Cardiomyopathy (DCMP)	1	0.5%	1	0.5%	2	0.5%
Truncus arteriosus	1	0.5%	1	0.5%	2	0.5%
DORV+VSD+PS	1	0.5%	0	0%	1	0.2%
Epstein anomaly	1	0.5%	0	0%	1	0.2%
Hypertrophic Cardiomyopathy (HCMP)	3	1.4%	0	0%	3	0.7%
Pulmonary Stenosis (PS)	2	0.9%	0	0%	2	0.5%
PS+VSD	1	0.5%	0	0%	1	0.2%

Single ventricle+heterotaxy syndrome	1	0.5%	0	0%	1	0.2%
Ventricular Septal Defect (VSD)	2	0.9%	3	1.4%	5	1.2%
Large Atrial Septal Defect 2 (ASD2)	2	0.9%	3	1.4%	5	1.2%
Coarctation Of Aorta (COA)	0	0%	1	0.5%	1	0.2%
Endocardial fibroelastosis+Aortic Stenosis (AS)	0	0%	1	0.5%	1	0.2%
Single ventricle	0	0%	1	0.5%	1	0.2%
rhabdomyoma	0	0%	1	0.5%	1	0.2%
Echogenic focus	11	5.1%	16	7.4%	27	6.3%
Total Anomalous Pulmonary Connections (TAPVC)	0	0%	1	0.5%	1	0.2%
Hypoplastic Right Heart Syndrome (HRHS)	0	0%	1	0.5%	1	0.2%
Bicuspid aortic valve+aortic stenosis (BAV+AS)	0	0%	1	0.5%	1	0.2%
Pulmonary atresia+VSD	1	0.5%	0	0%	1	0.2%
Shone complex (BAV+AS+COA)	0	0%	1	0.5%	0.5%	0.2%

4. Discussion

Congenital Heart Disease (CHD) is one of the most prevalent congenital anomalies worldwide, with an estimated incidence of 3.7-17.5 per 1000 live births, accounting for approximately 30-45% of all congenital malformations. CHDs often manifest early after birth and may progress to heart failure when combined with additional factors such as hypertension or infection. Despite advances in diagnosis and treatment, most individuals with CHD experience chronic complications requiring lifelong follow-up and management **(16)**. Therefore, strategies and identification of modifiable maternal risk factors remain essential in reducing CHD burden. A major limitation in many previous studies on CHD etiologies and their maternal pathologies is the lack of data on pregnancies resulting in stillbirth. Because both maternal obesity and fetal CHD are associated with stillbirth, excluding these cases may underestimate the true prevalence of CHD. The use of fetal echocardiography in the present study helps address this limitation by enabling diagnosis prior to delivery **(13)**. In our study, congenital heart abnormalities were detected in 33 fetuses of obese mothers (15.3%) and 37 fetuses of non-obese mothers (17.2%). Despite slight differences in distribution, no statistically significant association was found between maternal obesity and the overall incidence of CHD. Specific anomalies such as Hypertrophic Cardiomyopathy (HCMP), heterotaxy with single ventricle physiology, Tetralogy Of Fallot (TOF), congenital Dilated Cardiomyopathy (DCMP), truncus arteriosus, Double-Outlet Right Ventricle (DORV) with VSD and PSV, Ebstein anomaly, and pulmonary atresia with VSD were more frequently observed in obese mothers. Conversely, large ASD II, VSD, Coarctation of the Aorta (COA), Bicuspid Aortic Valve with Aortic Stenosis (BAV+AS), endocardial fibroelastosis, Hypoplastic Right Heart Syndrome (HRHS), shone complex (BAV+AS+COA), single ventricle physiology, Total Anomalous Pulmonary Venous Connection (TAPVC), rhabdomyoma, and echogenic focus were more common in non-obese mothers. No significant differences were observed for AVSD and HLHS between the two groups. The overall CHD prevalence in our study population (16.3%) was higher than reported in many previous studies. This could be due to our study population criteria, which included pregnant mothers referred to the pediatric heart clinic most likely because a suspicious finding had been detected in prior evaluations by obstetricians and gynecologists and were subsequently sent for further cardiac assessment. Therefore, while absolute prevalence cannot be generalized to the broader population, the comparative analysis between obese and non-obese mothers remains valid, given the similarity between groups in maternal age and parity. In our study, no statistically significant association was

found between maternal obesity and fetal Congenital Heart Disease (CHD). In contrast, Martin Persson et al., reported that the risk of CHD increased proportionally with the severity of maternal obesity (17). Their research, similar to ours, was a retrospective cohort study in which maternal height and weight during the first trimester were recorded. In our study, no relationship was observed between maternal age and the frequency of fetal CHD, and the same finding was reported by Martin Persson et al., Likewise, no significant association was found between the number of previous pregnancies and the incidence of CHD in infants. In another study by Mills et al., which examined 7392 newborns using a case–control design, obese mothers were found to be at a higher risk of having infants with CHD. However, our study did not demonstrate such an association (18). One possible explanation for the discrepancy between our findings and previous research is the smaller sample size in our study; a larger population may yield more robust and accurate results. A notable limitation of Mills et al., study was that only postnatal echocardiography results were included, meaning pregnancies ending in stillbirth were not captured. Since both maternal obesity and CHD can contribute to stillbirth, excluding these cases may have led to an underestimation of CHD prevalence among infants of obese mothers. A 2019 dose-response meta-analysis, unlike previous cohort or case–control studies, systematically reviewed and rated prior research. This analysis included six cohort studies and thirteen case-control studies. Of these, nine studies reported a clear association between increasing maternal BMI and higher CHD risk, while ten studies did not identify such a relationship. After integrating all available evidence, the authors concluded that CHD risk increases by 8% in overweight mothers and 23% in obese mothers compared with mothers of normal weight. They also found that study design did not significantly influence the results (3). In a study conducted by Qadirian et al., in Iran in 2014, involving 164 infants, no association was found between maternal obesity and increased CHD risk. Similar to our study, their research was limited by a small sample size, suggesting that larger study populations may yield more reliable results. Another similarity is that both studies were conducted in Iran; however, according to the 2019 integrated analysis, neither study location nor design significantly affected outcomes (4). A 2021 study by Taylor et al., also found no association between maternal obesity and increased fetal CHD risk. Similar to our methodology, fetal echocardiography during pregnancy was used to diagnosis (19). Considering the conflicting findings across similar studies, it appears that more comprehensive research is needed. Larger sample sizes, prospective designs, and inclusion of additional influencing factors may help produce more accurate and generalizable results.

This study examined the relationship between maternal obesity (BMI≥30) and the occurrence of Congenital Heart Defects (CHD) in newborns. Although certain anomalies such as Hypertrophic Cardiomyopathy (HCMP) and Tetralogy Of Fallot (TOF) were more frequently observed in obese mothers, no statistically significant overall association was found between maternal obesity and CHD. Limitations included a small sample size, exclusion of stillbirths, and potential selection bias. Future studies should incorporate larger cohorts, prospective designs, and additional risk factors such as diabetes and hypertension. Nevertheless, accurate prenatal screening and promoting healthy weight management and lifestyle choices among pregnant women remain practical strategies to reduce CHD risk and improve maternal and fetal outcomes.

5. Conclusion

In this retrospective cohort study, congenital heart defects were identified in 15.3% of fetuses of obese mothers 17.2% of fetuses of non-obese mothers. No statistically significant association was found between maternal obesity and the incidence of CHD (P=0.601). Structural cardiac anomalies were slightly more frequent in obese mothers (8.8% vs. 7.4%), but this difference was also not statistically significant (P=0.597).

6. Declarations

Acknowledgments

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Ethical Considerations

This study was approved by the Ethics Committee of Qom University of Medical Sciences (Code: IR.MUQ.REC.1402.093).

Authors' Contributions

All authors contributed equally to the preparation of this manuscript.

Conflict of Interest

The authors declare no conflict of interest.

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