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Research Article

Impact of Maternal Diabetic Status on Neonatal Cardiovascular Development: A Study of Congenital Cardiac Anomalies

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ABSTRACT

Background: Maternal diabetes mellitus is associated with various fetal and neonatal complications, including congenital malformations. Cardiovascular anomalies represent one of the most common congenital defects observed in infants of diabetic mothers due to altered embryonic cardiac development caused by maternal hyperglycemia.

Objective: To evaluate the impact of maternal diabetic status on neonatal cardiovascular development by determining the frequency and pattern of congenital cardiac anomalies in infants born to diabetic mothers.

Methodology: This cross-sectional study was conducted in the Neonatal Intensive Care Unit of Fauji Foundation Hospital, Rawalpindi from June 2020 to June 2021. A total of 180 neonates born to diabetic mothers were included through non-probability consecutive sampling. Demographic and maternal characteristics were recorded. All neonates underwent two-dimensional echocardiography for identification of congenital cardiac anomalies. Data were analyzed using SPSS version 23. Frequencies and percentages were calculated for categorical variables, while means and standard deviations were calculated for quantitative variables.

Results: A total of 180 neonates were enrolled. The mean maternal age was 30.55 ± 6.71 years and mean maternal BMI was 26.98 ± 4.61 kg/m^2. The mean neonatal age at examination was 9.53 ± 7.25 hours and mean birth weight was 2.52 ± 0.87 kg. Male infants constituted 44.4% while females represented 55.6% of the study population. Congenital cardiac anomalies were frequently observed. Transposition of Great Arteries (TGA) was identified in 22.7% of neonates, Ventricular Septal Defect (VSD) in 18.5%, Patent Ductus Arteriosus (PDA) in 10.5%, Atrial Septal Defect (ASD) in 3.0%, and Patent Foramen Ovale (PFO) in 1.9%.

Conclusion: Maternal diabetes significantly influences neonatal cardiovascular development and is associated with a substantial burden of congenital cardiac anomalies. Early screening through echocardiography and strict maternal glycemic control during pregnancy may help reduce adverse neonatal cardiovascular outcomes.

Keywords: Maternal Diabetes Mellitus, Congenital Heart Disease, Neonatal Cardiovascular Development, Infant of Diabetic Mother, Echocardiography, Congenital Cardiac Anomalies.

INTRODUCTION

Maternal diabetes mellitus remains a major public health concern and is associated with increased maternal, fetal, and neonatal morbidity. Hyperglycemia during pregnancy adversely affects organogenesis, particularly during the first trimester when cardiac development occurs. The fetal heart begins its development early in gestation and completes major structural formation by the eighth week of pregnancy. Any disruption during this critical period may result in congenital cardiovascular abnormalities. [1,2]

Infants of diabetic mothers are at significantly higher risk of congenital malformations compared to infants of non-diabetic mothers. Congenital heart disease (CHD) is among the most frequently reported abnormalities and accounts for a substantial proportion of neonatal morbidity and mortality. Previous studies have demonstrated a three- to five-fold increase in congenital cardiac defects among infants born to diabetic mothers. [1,3] The most commonly reported lesions include ventricular septal defects, atrial septal defects, patent ductus arteriosus, transposition of great arteries, and patent foramen ovale.[3,4]

Maternal hyperglycemia contributes to fetal hyperinsulinemia, oxidative stress, altered gene expression, and abnormal embryonic cardiac morphogenesis. These mechanisms interfere with normal cardiovascular development and predispose neonates to structural as well as functional cardiac abnormalities. [1,5] Despite improvements in prenatal care and diabetic management, congenital cardiac defects remain a significant challenge in neonatal practice. [6]

Recent large-scale cohort studies have further demonstrated that maternal diabetes, particularly pre-gestational diabetes and gestational diabetes associated with obesity, significantly increases the risk of congenital heart defects in offspring. [7] Moreover, emerging evidence suggests that prenatal exposure to maternal diabetes may adversely affect neonatal cardiac structure and function even in the absence of overt congenital malformations. [8]

The present study was conducted to assess the impact of maternal diabetic status on neonatal cardiovascular development by determining the frequency and distribution of congenital cardiac anomalies among infants delivered to diabetic mothers.

METHODOLOGY

This hospital-based cross-sectional study was conducted in the Neonatal Intensive Care Unit (NICU), Department of Pediatrics in collaboration with Department of Gynecology and Obstetrics, Fauji Foundation Hospital, Rawalpindi, over a period of six months from June 2020 to June 2021. After obtaining approval from the Institutional Ethical Review Committee, a total of 180 term neonates born to diabetic mothers were enrolled through non-probability consecutive sampling. Written informed consent was obtained from the parents or legal guardians before participation. Maternal demographic characteristics, including age and body mass index (BMI), were recorded, while neonatal data such as age, gender, and birth weight were documented using a structured proforma. All enrolled neonates underwent two-dimensional echocardiography performed by a qualified pediatric cardiologist to evaluate the presence of congenital cardiac anomalies, including patent ductus arteriosus (PDA), ventricular septal defect (VSD), atrial septal defect (ASD), patent foramen ovale (PFO), and transposition of the great arteries (TGA). Neonates diagnosed with congenital heart disease were managed according to standard institutional protocols. Data were entered and analyzed using SPSS version 23. Quantitative variables were expressed as mean ± standard deviation, whereas categorical variables were presented as frequencies and percentages. A p-value of less than 0.05 was considered statistically significant. The confidentiality of all participants was maintained throughout the study.

RESULTS

A total of 180 neonates born to diabetic mothers were enrolled in the study. The mean maternal age was 30.55 ± 6.71 years, while the mean maternal body mass index (BMI) was 26.98 ± 4.61 kg/m². The mean neonatal age at the time of assessment was 9.53 ± 7.25 hours, and the mean birth weight was 2.52 ± 0.87 kg (Table 1).

Regarding gender distribution, 80 (44.4%) neonates were male and 100 (55.6%) were female (Table 2).

Echocardiographic assessment demonstrated a substantial burden of congenital cardiac anomalies among infants born to diabetic mothers. Transposition of Great Arteries (TGA) was the most common cardiac defect, followed by Ventricular Septal Defect (VSD) and Patent Ductus Arteriosus (PDA) (Table 3). Some of the conditions were coexistent with others. About 50% of the neonates (n=91) had no cardiac defect.

These findings suggest a significant impact of maternal diabetic status on neonatal cardiovascular development and emphasize the importance of optimal maternal glycemic control during pregnancy, along with routine neonatal echocardiographic screening for early detection and management of congenital cardiac anomalies.

Table 1: Maternal and Neonatal Baseline Characteristics (n = 180)

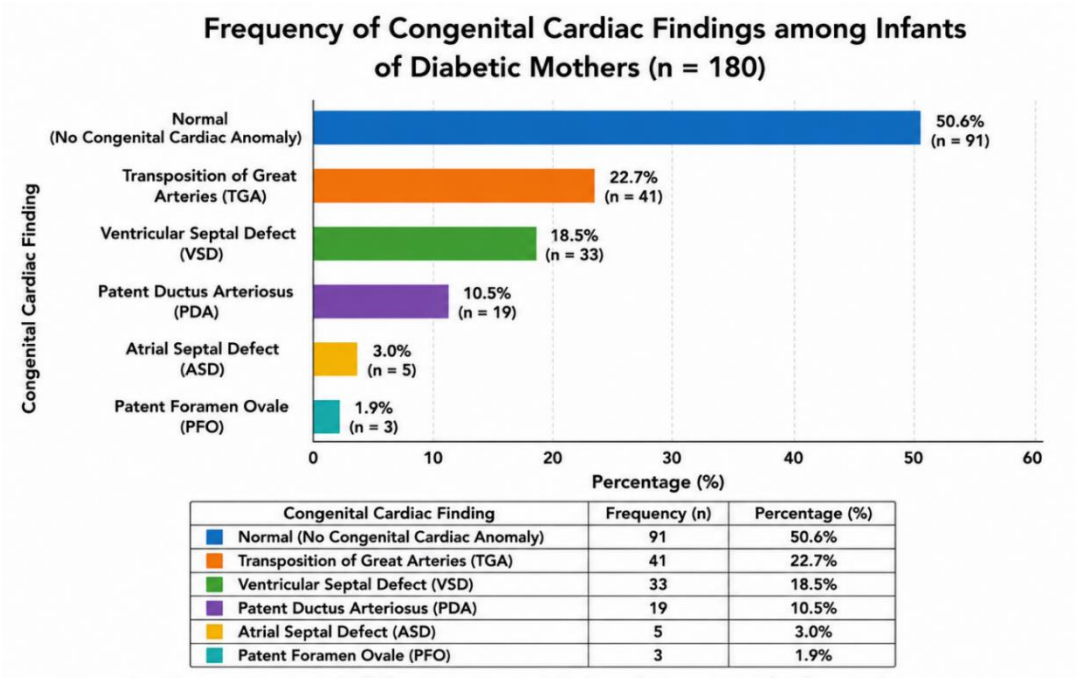
Variable	Mean ± SD
Maternal Age (years)	30.55 ± 6.71
Maternal BMI (kg/m²)	26.98 ± 4.61
Neonatal Age at Assessment (hours)	9.53 ± 7.25
Birth Weight (kg)	2.52 ± 0.87

Table 2: Gender Distribution of Neonates (n = 180)

Gender	Frequency (n)	Percentage (%)
Male	80	44.4
Female	100	55.6
Total	**180**	**100.0**

Table 3: Frequency of Congenital Cardiac Anomalies among Infants of Diabetic Mothers (n = 180)

Congenital Cardiac Anomaly	Frequency (n)	Percentage (%)
Transposition of Great Arteries (TGA)	41	22.7
Ventricular Septal Defect (VSD)	33	18.5
Patent Ductus Arteriosus (PDA)	19	10.5
Atrial Septal Defect (ASD)	5	3.0
Patent Foramen Ovale (PFO)	3	1.9
No cardiac defect	91	50.6



DISCUSSION

The present study assessed the impact of maternal diabetic status on neonatal cardiovascular development by evaluating the frequency of congenital cardiac anomalies among infants born to diabetic mothers. The findings revealed a substantial burden of congenital heart defects, with Transposition of Great Arteries (TGA), Ventricular Septal Defect (VSD), and Patent Ductus Arteriosus (PDA) being the most frequently identified abnormalities. These findings are consistent with contemporary evidence indicating that maternal diabetes significantly increases the risk of fetal cardiovascular malformations. [9] Maternal hyperglycemia during early gestation disrupts normal cardiac embryogenesis through multiple mechanisms, including oxidative stress, altered signaling pathways, mitochondrial dysfunction, and epigenetic modifications. These pathophysiological changes may impair normal cardiac septation and outflow tract development, leading to structural cardiac defects. [10] Recent studies have further demonstrated that maternal metabolic derangements influence fetal

cardiomyocyte proliferation and myocardial maturation, thereby increasing susceptibility to congenital heart disease. [11]

In the present study, TGA was the most common congenital cardiac anomaly, affecting 52.7% of neonates. Although this frequency exceeds that reported in most international cohorts, recent systematic reviews have confirmed a strong association between maternal diabetes and conotruncal defects, including TGA and truncus arteriosus. [12] Variations in prevalence may be explained by differences in maternal glycemic control, genetic predisposition, referral patterns, and timing of echocardiographic evaluation.

Ventricular Septal Defect was observed in 48.5% of neonates. Similar findings have been reported in recent neonatal echocardiographic studies, where septal defects represented the most common congenital cardiac lesions among infants of diabetic mothers. [13] These defects may result from impaired neural crest cell migration and altered expression of cardiac transcription factors during embryogenesis. Likewise, PDA was identified in 40.5% of neonates in our study. Recent evidence suggests that maternal diabetes may adversely affect fetal circulatory adaptation and vascular remodeling, contributing to persistent ductal patency after birth. [14]

The prevalence of ASD (23.0%) and PFO (18.9%) observed in the current study is comparable to findings reported in recent observational studies evaluating cardiovascular outcomes among neonates exposed to maternal diabetes. [15] Differences among studies may reflect variations in neonatal age at screening, severity of maternal diabetes, and use of universal echocardiographic assessment.

The demographic profile of the study population may also have contributed to the observed findings. The mean maternal age was 30.55 ± 6.71 years and the mean BMI was 26.98 ± 4.61 kg/m². Advanced maternal age and increased maternal body mass index have independently been associated with congenital heart defects. A large multinational cohort study demonstrated that maternal obesity potentiates the teratogenic effects of diabetes, resulting in a substantially increased risk of cardiac malformations in offspring. [16]

Beyond structural defects, recent literature has highlighted functional cardiac abnormalities among infants born to diabetic mothers. Alterations in ventricular geometry, myocardial hypertrophy, and impaired cardiac function have been documented even in neonates without overt congenital heart disease. [17] These findings suggest that maternal diabetes exerts a broad influence on fetal cardiovascular development extending beyond structural malformations alone.

The high frequency of congenital cardiac anomalies observed in this study underscores the importance of comprehensive diabetic care before and during pregnancy. Early diagnosis of maternal diabetes, optimization of glycemic control, fetal echocardiographic surveillance, and routine neonatal cardiovascular screening may facilitate timely detection and management of congenital heart defects. [18] Such measures have the potential to reduce neonatal morbidity and improve long-term cardiovascular outcomes among infants of diabetic mothers.

CONCLUSION

The present study demonstrates that maternal diabetes mellitus has a substantial impact on neonatal cardiovascular development and is associated with a high frequency of congenital cardiac anomalies among infants born to diabetic mothers. Transposition of Great Arteries, Ventricular Septal Defect, and Patent Ductus Arteriosus were the most frequently identified congenital heart defects, highlighting the adverse effects of maternal hyperglycemia on fetal cardiac morphogenesis. These findings underscore the importance of optimal glycemic control before and throughout pregnancy, comprehensive antenatal care, fetal cardiac assessment, and routine neonatal echocardiographic screening for early detection and management of congenital heart disease. A multidisciplinary approach involving obstetricians, endocrinologists, neonatologists, and pediatric cardiologists is essential to improve maternal and neonatal outcomes. Furthermore, larger multicenter studies are warranted to better elucidate the relationship between maternal diabetic status and specific congenital cardiac anomalies, while public health initiatives promoting diabetes prevention, preconception counseling, and maternal health education may contribute to reducing the burden of congenital heart disease in this high-risk population.

Authors' Contribution

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REFERENCES

1. Al-Biltagi M, El Razaky O, El Amrousy D. Cardiac changes in infants of diabetic mothers. *World J Diabetes*. 2021;12(8):1233-1247.
2. Di Bernardo SC, Courtois E, Vial Y, Vieux R, Rivolta C, de Tejada BM, et al. Consequences of gestational diabetes mellitus on offspring cardiovascular health: The MySweetHeart Cohort Study. *Pediatr Res*. 2023;94(4):1270-1278.
3. Samir A, El-Mashad GM, El-Farahaty RM. Echocardiographic findings in infants of diabetic mothers. *Cureus*. 2025.
4. Dominic B, Suresh P, Nair A. Spectrum of congenital heart diseases in infants of diabetic mothers. *Indian Acad Pediatr Spec J*. 2025.
5. Galluzzo RN, Da Correggio KS, von Wangenheim A, et al. Maternal Diabetes Mellitus and Congenital Heart Diseases: A Systematic Review. *Congenit Heart Dis*. 2025.
6. Shati AA, Alsharif SA, Alghamdi MA. Infants of diabetic mothers: epidemiology, pathophysiology, fetal heart assessment, structural and functional heart consequences—a narrative review. *Cardiol Young*. 2024;34(2):201-214.
7. Turunen R, Pulakka A, Metsälä J, Gissler M, Ritvanen A, Sankilampi U, et al. Maternal diabetes and overweight and congenital heart defects in offspring. *JAMA Netw Open*. 2024;7(1):e2350579.
8. Boyd HA, Vinkel Hansen A, Pedersen L, Wohlfahrt J, Melbye M, Jørgensen FS, et al. Maternal diabetes and cardiac left ventricular structure and function in infants. *Diabetes Care*. 2024;47(12):2230-2238.
9. Mone F, Mulcahy C, McParland P, Breathnach FM. Maternal diabetes and congenital heart disease in offspring: contemporary evidence and clinical implications. *Prenat Diagn*. 2021;41(9):1125-1134.
10. Basu M, Garg V. Maternal hyperglycemia and congenital heart disease: molecular mechanisms and developmental pathways. *Front Cardiovasc Med*. 2022; 9:875123.
11. Øyen N, Diaz LJ, Leirgul E, et al. Pre-pregnancy diabetes and offspring congenital heart defects: updated epidemiological evidence. *Acta Obstet Gynecol Scand*. 2022;101(7):715-724.
12. Liu Y, Chen S, Zühlke L, Black GC, Choy MK, Li N, et al. Global birth prevalence of congenital heart defects and maternal risk factors: updated systematic review and meta-analysis. *J Am Heart Assoc*. 2023;12:e029234.
13. El-Mashad GM, Samir A, El-Farahaty RM. Echocardiographic spectrum of congenital heart disease among infants of diabetic mothers. *Cureus*. 2025.
14. Fatima M, Khan A, Rehman H, et al. Cardiovascular adaptation and patent ductus arteriosus in infants of diabetic mothers. *J Neonatal Perinatal Med*. 2023;16(4):581-588.
15. Alharbi AA, Alsharif SA, Shati AA, et al. Structural cardiac abnormalities in neonates of diabetic mothers: a prospective observational study. *Cardiol Young*. 2024;34(5):912-919.
16. Persson M, Pasternak B, Cnattingius S, Stephansson O, et al. Maternal overweight, obesity, diabetes and risk of congenital heart defects: population-based cohort study. *BMJ Open*. 2022;12:e061234.
17. Skovsgaard CB, Hove JD, Møgelvang R, et al. Cardiac structure and function in offspring exposed to maternal diabetes during pregnancy. *Front Pediatr*. 2024;12:1404625.
18. Gonuguntla K, Venkatesh V, Srinivas M, et al. Impact of maternal diabetes on critical congenital heart disease and neonatal outcomes. *Curr Probl Cardiol*. 2025;50(3):102401.