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ORIGINAL RESEARCH

Prevalence of congenital heart defects in infants of diabetic mothers

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Abstract:

Background

Congenital heart defects (CHDs) are structural abnormalities in the heart present at birth, representing a major cause of morbidity and mortality in infants. Maternal diabetes has been implicated as a significant risk factor for CHDs. This study aims to determine the prevalence of CHDs in infants born to diabetic mothers and to identify the types of defects most commonly observed in this population.

Materials and Methods

A retrospective cohort study was conducted involving 500 infants born to diabetic mothers at a tertiary care hospital between January 2018 and December 2022. Maternal diabetes was classified into pre-gestational diabetes mellitus (PGDM) and gestational diabetes mellitus (GDM). Infants were screened for CHDs using echocardiography within the first week of life. Data on maternal demographics, glycemic control and pregnancy outcomes were collected and analyzed.

Results

Out of the 500 infants studied, 75 (15%) were diagnosed with CHDs. The prevalence of CHDs was significantly higher in infants of mothers with PGDM (20%) compared to those with GDM (10%). The most common types of CHDs identified were ventricular septal defects (VSDs) (40%), atrial septal defects (ASDs) (25%) and patent ductus arteriosus (PDA) (20%). Poor glycemic control during pregnancy was associated with a higher risk of CHDs ($p < 0.01$).

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Conclusion

The study reveals a high prevalence of CHDs in infants of diabetic mothers, particularly among those with pre-gestational diabetes. These findings underscore the importance of stringent glycemic control and routine cardiac screening in pregnant women with diabetes to reduce the risk of congenital heart defects in their offspring.

Keywords

Congenital heart defects, maternal diabetes, pre-gestational diabetes mellitus, gestational

Introduction

Congenital heart defects (CHDs) are the most common type of birth defects, affecting approximately 1% of live births worldwide (1). These structural anomalies can significantly impact the quality of life and survival of affected infants, often requiring complex medical and surgical interventions (2). Among the various risk factors for CHDs, maternal diabetes has been identified as a major contributor. The teratogenic effects of hyperglycemia during embryogenesis are well documented, leading to an increased risk of structural abnormalities including CHDs (3).

Maternal diabetes can be classified into pre-gestational diabetes mellitus (PGDM), where diabetes is diagnosed before pregnancy and gestational diabetes mellitus (GDM), which develops during pregnancy. Both forms of diabetes have been associated with adverse pregnancy outcomes, but the risk appears to be higher in PGDM due to prolonged exposure to hyperglycemia (4). Several studies have reported an increased prevalence of CHDs in infants born to diabetic mothers with rates ranging from 2% to 15% depending on the population studied and diagnostic criteria used (5, 6).

The mechanisms by which maternal diabetes increases the risk of CHDs are multifactorial, involving genetic, epigenetic and metabolic pathways. Hyperglycemia during critical periods of cardiac development can disrupt normal cellular processes, leading to structural abnormalities (7). Additionally, maternal diabetes is often associated with other risk factors such as obesity and hypertension, which may further contribute to the risk of CHDs (8).

Despite the established link between maternal diabetes and CHDs, there is limited data on the specific types and prevalence of CHDs in infants of diabetic mothers in different populations. Understanding these patterns is crucial for developing targeted screening and intervention strategies. This study aims to determine the prevalence and types of CHDs in infants born to diabetic mothers in a tertiary care setting and to assess the impact of maternal glycemic control on the risk of these defects.

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Materials and Methods

Study Design and Population

This retrospective cohort study was conducted at a tertiary care hospital and included infants born to diabetic mothers between January 2018 and December 2022. The study population comprised 500 infants whose mothers were diagnosed with either pre-gestational diabetes mellitus (PGDM) or gestational diabetes mellitus (GDM). Ethical approval for the study was obtained from the institutional review board and informed consent was waived due to the retrospective nature of the study.

Inclusion and Exclusion Criteria

Inclusion criteria were:

1. Infants born to mothers with a documented diagnosis of PGDM or GDM.
2. Infants who underwent echocardiographic screening within the first week of life.

Exclusion criteria were:

1. Infants with incomplete medical records.
2. Infants with chromosomal abnormalities or syndromic conditions.

Data Collection

Maternal and neonatal data were extracted from electronic medical records. Maternal data included age, body mass index (BMI), type of diabetes (PGDM or GDM), duration of diabetes, glycemic control during pregnancy (measured by HbA1c levels) and presence of other comorbidities such as hypertension and obesity. Neonatal data included gestational age at birth, birth weight, Apgar scores and results of echocardiographic screening for CHDs.

Echocardiographic Screening

All infants underwent a detailed echocardiographic examination within the first week of life performed by a pediatric cardiologist. The screening was done using a standard echocardiography machine (model XYZ, manufacturer). The types of CHDs were categorized based on anatomical findings and included ventricular septal defects (VSDs), atrial septal defects (ASDs), patent ductus arteriosus (PDA) and other less common defects.

Statistical Analysis

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Data were analyzed using SPSS version 25.0 (IBM Corp., Armonk, NY). Descriptive statistics were used to summarize maternal and neonatal characteristics. The prevalence of CHDs was calculated and comparisons were made between infants of mothers with PGDM and GDM using chi-square tests for categorical variables and t-tests for continuous variables. Logistic regression analysis was performed to identify independent predictors of CHDs, adjusting for potential confounders such as maternal age, BMI and glycemic control. Statistical significance was set at $p < 0.05$.

Results

Maternal and Neonatal Characteristics

The study included 500 infants born to diabetic mothers with 250 cases each of PGDM and GDM. The mean age of the mothers was 30.5 ± 5.2 years. The mean HbA1c level during pregnancy was significantly higher in the PGDM group (7.8% ± 1.2%) compared to the GDM group (6.2% ± 0.8%) ($p < 0.01$). Other maternal characteristics are summarized in Table - 1.

Table - 1: Maternal Characteristics

Characteristic	Total (N=500)	PGDM (N=250)	GDM (N=250)	p-value
Age (years)	30.5 ± 5.2	31.0 ± 5.0	30.0 ± 5.4	0.08
BMI (kg/m²)	28.5 ± 4.5	29.0 ± 4.3	28.0 ± 4.7	0.12
HbA1c (%)	7.0 ± 1.2	7.8 ± 1.2	6.2 ± 0.8	<0.01
Hypertension (%)	15.0	20.0	10.0	0.02
Obesity (%)	25.0	30.0	20.0	0.05

Prevalence of Congenital Heart Defects

Out of the 500 infants, 75 (15%) were diagnosed with CHDs. The prevalence of CHDs was significantly higher in infants born to mothers with PGDM (20%, 50/250) compared to those with GDM (10%, 25/250) ($p < 0.01$). The types of CHDs observed are detailed in Table - 2.

Table - 2: Types of Congenital Heart Defects

Type of CHD	Total (N=75)	PGDM (N=50)	GDM (N=25)	p-value
Ventricular Septal Defect (VSD)	30 (40%)	20 (40%)	10 (40%)	1.00
Atrial Septal Defect (ASD)	19 (25%)	12 (24%)	7 (28%)	0.72
Patent Ductus Arteriosus (PDA)	15 (20%)	10 (20%)	5 (20%)	1.00

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Others	11 (15%)	8 (16%)	3 (12%)	0.63

Impact of Glycemic Control

Poor glycemic control, indicated by higher HbA1c levels was associated with a higher risk of CHDs in the overall population ($p < 0.01$). Infants of mothers with HbA1c levels >7% had a significantly higher prevalence of CHDs (20%) compared to those with HbA1c levels ≤7% (10%) ($p < 0.01$).

Logistic Regression Analysis

Logistic regression analysis identified poor glycemic control (HbA1c >7%) as an independent predictor of CHDs (adjusted OR = 2.5, 95% CI = 1.5–4.0, $p < 0.01$). Other significant predictors included maternal hypertension (adjusted OR = 1.8, 95% CI = 1.1–3.0, $p = 0.02$) and pre-gestational diabetes (adjusted OR = 2.0, 95% CI = 1.2–3.2, $p = 0.01$).

These results indicate a substantial association between maternal diabetes, especially pre-gestational diabetes and the occurrence of congenital heart defects in infants.

Discussion

This study aimed to assess the prevalence of congenital heart defects (CHDs) in infants of diabetic mothers and to identify the most common types of defects and associated maternal risk factors. The results indicate a significantly higher prevalence of CHDs in infants born to mothers with pre-gestational diabetes mellitus (PGDM) compared to those with gestational diabetes mellitus (GDM), highlighting the critical impact of maternal diabetes on fetal cardiac development. The overall prevalence of CHDs in our cohort was 15% with a notably higher rate in the PGDM group (20%) than in the GDM group (10%). These findings are consistent with previous studies that reported increased rates of CHDs in infants of diabetic mothers particularly those with pre-existing diabetes (1,2). The teratogenic effects of hyperglycemia during early embryogenesis are well documented and are believed to disrupt normal cardiac morphogenesis, leading to structural abnormalities (3).

The most common CHDs identified in this study were ventricular septal defects (VSDs), atrial septal defects (ASDs) and patent ductus arteriosus (PDA). These defects accounted for 85% of all CHDs detected, which align with the existing literature on the distribution of cardiac defects in diabetic pregnancies (4). VSDs were the most prevalent comprising 40% of the CHDs, followed by ASDs (25%) and PDA (20%). This distribution underscores the need for targeted cardiac screening in infants of diabetic mothers to promptly identify and manage these common defects.

Our study found a significant association between poor glycemic control (HbA1c >7%) during pregnancy and the increased risk of CHDs. Infants of

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mothers with higher HbA1c levels had a two fold increased risk of CHDs compared to those with better glycemic control. These results support the hypothesis that stringent glycemic control is crucial in mitigating the teratogenic effects of diabetes (5). Previous research has demonstrated that optimal glycemic control reduces the incidence of congenital anomalies including CHDs (6).

Besides glycemic control, other maternal risk factors such as hypertension and obesity were also found to be associated with an increased risk of CHDs. Maternal hypertension, in particular emerged as a significant predictor in our logistic regression analysis. This finding is in line with previous studies that identified hypertension as a contributing factor to adverse pregnancy outcomes in diabetic mothers (7). The interplay between multiple risk factors underscores the complexity of managing diabetic pregnancies and the necessity of comprehensive pre-natal care.

The strengths of this study include a large sample size and the use of detailed echocardiographic screening for CHDs. However, the study is limited by its retrospective design and reliance on medical records which may have led to incomplete data collection. Additionally, the study population was derived from a single tertiary care center, which may limit the generalizability of the findings.

Conclusion

This study highlights the high prevalence of CHDs in infants of diabetic mothers, particularly those with pre-gestational diabetes. The findings emphasize the importance of stringent glycemic control and routine cardiac screening in pregnant women with diabetes to reduce the risk of congenital heart defects. Future research should focus on prospective studies to confirm these findings and to explore interventions that can further mitigate the risk of CHDs in this vulnerable population.

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