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FETAL ECHOCARDIOGRAPHIC ANALYSIS OF MYOCARDIAL THICKNESS AND SEPTAL INTEGRITY IN GESTATIONAL DIABETIC PATIENTS AND ITS ASSOCIATION WITH FAMILY HISTORY OF DIABETES

Original Research

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ABSTRACT

Background: Gestational diabetes mellitus (GDM) is a frequent metabolic complication of pregnancy and is strongly linked to adverse fetal outcomes, including structural and functional cardiac alterations. While the impact of maternal hyperglycemia on fetal cardiac development has been extensively documented, the additional role of genetic predisposition through a positive family history of diabetes (FHD) has received limited attention. Investigating this interaction is particularly important in high-risk populations such as Pakistan, where diabetes prevalence is alarmingly high.

Objective: The objective of this study was to evaluate fetal echocardiographic parameters, including interventricular septal (IVS) thickness, left ventricular end-diastolic diameter (LVDd), ejection fraction (EF), and fractional shortening (FS), and to determine their association with family history of diabetes in women with GDM.

Methods: A prospective cross-sectional study was carried out in the Echocardiography Department of The Children's Hospital, Lahore, over a two-month period. A total of 89 pregnant women aged 20–45 years with singleton pregnancies between 18–36 weeks of gestation were recruited using purposive sampling. Fetal echocardiography was performed using a 3–5 MHz transducer, with standard cardiac views and Doppler assessment to measure IVS thickness, LVDd, EF, and FS. Maternal demographic data and family history of diabetes were systematically recorded. Statistical analysis was conducted using SPSS version 30, applying descriptive statistics and Chi-square tests, with significance set at $p < 0.05$.

Results: Among the 89 participants, 77 (86.5%) reported a positive FHD and 12 (13.5%) had no such history. Septal hypertrophy was identified in 74 women (83.15%) with FHD compared to 9 (10.11%) without, demonstrating a significant association ($p = 0.007$). LVDd values showed similar significance ($p = 0.006$), with 50 (56.18%) of women with FHD exhibiting reduced dimensions compared to 5 (5.62%) without. In contrast, EF and FS were preserved across both groups, showing no statistical association with family history ($p = 0.691$).

Conclusion: The study concluded that GDM in combination with a positive family history of diabetes significantly influenced fetal cardiac morphology, particularly septal hypertrophy and reduced LVDd, while systolic parameters such as EF and FS remained unaffected. These findings highlight the importance of enhanced prenatal surveillance and targeted echocardiographic screening in high-risk pregnancies.

Keywords: Diabetes, Family History, Fetal Echocardiography, Gestational Diabetes Mellitus, Myocardial Hypertrophy, Pregnancy, Ventricular Function.

INTRODUCTION

Gestational diabetes mellitus (GDM) is a common metabolic disorder of pregnancy, defined as glucose intolerance with onset or first recognition during gestation (1). Its global prevalence has risen steadily, closely linked to the increasing burden of obesity and type 2 diabetes, thereby establishing GDM as a significant public health concern (2). The condition arises when maternal pancreatic β-cells fail to sufficiently compensate for the insulin resistance induced by placental hormones, resulting in maternal hyperglycemia (3). This metabolic imbalance exerts profound effects not only on maternal health but also on fetal development, predisposing the fetus to a wide spectrum of short- and long-term complications (4). The fetal heart is particularly sensitive to intrauterine metabolic stress, and maternal hyperglycemia is recognized as a teratogenic factor (5). Fetal hyperinsulinemia, triggered by maternal hyperglycemia, functions as a potent growth stimulator, leading to abnormal myocardial proliferation and hypertrophic cardiomyopathy, most prominently evident as interventricular septal (IVS) thickening (6,7). Beyond structural hypertrophy, fetuses of diabetic mothers frequently exhibit impaired diastolic function, reduced global longitudinal strain, and a more globular cardiac geometry, even when maternal glycemic control appears adequate (8). Such alterations may have lasting implications for cardiovascular health later in life.

In addition to the direct impact of hyperglycemia, genetic predisposition plays an important role in the pathogenesis of diabetes. A positive family history of diabetes (FHD) has consistently been associated with increased susceptibility to type 2 diabetes and GDM, underscoring its heritable component (9,10). It is plausible that this genetic background also modifies the fetal myocardium's response to intrauterine metabolic stress, amplifying structural and functional cardiac alterations otherwise attributed to GDM alone (11). Despite its potential clinical relevance, this interaction between GDM and family history in shaping fetal cardiac development remains poorly defined, especially in populations with high baseline rates of diabetes. Timely detection of GDM is therefore essential, as it can substantially reduce neonatal complications and stillbirths (12). Standard diagnostic strategies include the one-step 75 g oral glucose tolerance test (OGTT), where fasting, 1-hour, and 2-hour post-glucose blood samples are obtained; the diagnosis of GDM is made if any value exceeds established thresholds (13,14). In Pakistan, where diabetes is highly prevalent, GDM represents a pressing clinical challenge. However, local data addressing the combined influence of GDM and FHD on fetal cardiac morphology and function are scarce. This study seeks to bridge this gap by conducting detailed fetal echocardiographic assessments in Pakistani women with GDM, focusing on myocardial thickness and septal integrity. The primary objective is to evaluate whether a positive family history of diabetes is associated with greater alterations in these cardiac parameters, thereby identifying a potentially high-risk subgroup warranting closer prenatal surveillance and tailored clinical care.

METHODS

The study was conducted as a descriptive cross-sectional investigation in the Echocardiography Department of The Children's Hospital, Lahore, over a period of two months. A total of 89 pregnant women previously diagnosed with gestational diabetes mellitus were enrolled using purposive sampling. Women aged between 20 and 45 years with singleton pregnancies between 18 and 36 weeks of gestation were considered eligible. Exclusion criteria included patients with pre-existing diabetes, hypertension, other systemic co-morbidities, multiple gestations, or maternal age below 20 years. All participants provided informed written consent prior to enrolment, and the study protocol was reviewed and approved by the institutional ethical review committee. Fetal echocardiography was performed using a low-frequency transducer (3–5 MHz) with standard imaging protocols. Multiple cardiac views were obtained, including abdominal situs, four- and five-chamber views, right and left ventricular outflow tracts, and ductus arteriosus. These views were assessed to evaluate myocardial wall thickness, interventricular septal integrity, and overall cardiac structure. Doppler ultrasound was additionally employed to assess intracardiac and great vessel blood flow patterns. All examinations were performed by trained sonographers under standardized conditions to ensure consistency in measurements. Maternal demographic data, gestational age, and detailed echocardiographic findings were systematically recorded. Data were entered into SPSS version 30 for statistical analysis. Descriptive statistics were applied to summarize demographic and echocardiographic variables, while cross-tabulation and Chi-square tests were performed to determine the association between a positive family history of diabetes and fetal cardiac parameters. Statistical significance was set at $p < 0.05$.

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RESULTS

The study enrolled 89 pregnant women with gestational diabetes, of whom 77 (86.5%) reported a positive family history of diabetes, while 12 (13.5%) did not. Septal hypertrophy was observed in 74 women (83.1%) with a family history and in 9 women (10.1%) without such a history, whereas normal septal thickness was present in only 3 women (3.4%) in each group. The association between family history and septal hypertrophy was statistically significant (p = 0.007). Analysis of left ventricular diastolic diameter (LVDd) further demonstrated a significant association with family history (p = 0.006). Among participants with a positive family history, 25 (28.1%) had normal LVDd, 50 (56.2%) exhibited decreased values, and 2 (2.3%) had increased measurements. In contrast, among those without a family history, 4 (4.5%) had normal LVDd, 5 (5.6%) had decreased, and 3 (3.4%) showed increased values. Ejection fraction and fractional shortening were largely within normal ranges irrespective of family history, with 76 (85.4%) participants in the positive history group and all 12 (13.5%) in the negative history group demonstrating normal values. Only one participant (1.1%) with a family history had reduced ejection fraction. This relationship was not statistically significant (p = 0.691).

Table 1: Distribution of Family History of Diabetes Among Pregnant Women with Gestational Diabetes Mellitus

Family History of Diabetes	Frequency	Percentage (%)
Yes	77	86.51
No	12	13.49
Total	89	100%

Table 2: Association of Family History of Diabetes with Septal Thickness in Fetuses of Mothers with Gestational Diabetes Mellitus

Family History of Diabetes	Septal Thickness	Frequency	Percentage (%)
Yes	Normal	3	3.37
	Hypertrophy	74	83.15
No	Normal	3	3.37
	Hypertrophy	9	10.11

Table 3: Association of Family History of Diabetes with Septal Thickness and Left Ventricular Diastolic Diameter in Fetuses of Mothers with Gestational Diabetes Mellitus

Family History of Diabetes	Septal Thickness	Frequency	Percentage (%)	P value
Yes	Normal	3	3.37	0.007
	Hypertrophy	74	83.15	
No	Normal	3	3.37	
	Hypertrophy	9	10.11	
Family History of Diabetes	LVDd	Frequency	Percentage (%)	P value
Yes	Normal	25	28.09	0.006
	Increase	2	2.25	
	Decrease	50	56.18	

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Family History of Diabetes	Septal Thickness	Frequency	Percentage (%)	P value
No	Normal	4	4.49	
	Increase	3	3.37	
	Decrease	5	5.62	

Table 4: Association of Family History of Diabetes with Fetal Ejection Fraction in Gestational Diabetes Mellitus

Family History of Diabetes	EF	Frequency	Percentage (%)	P value
Yes	Normal	76	85.39	0.691
	Low	1	1.12	
No	Normal	12	13.48	

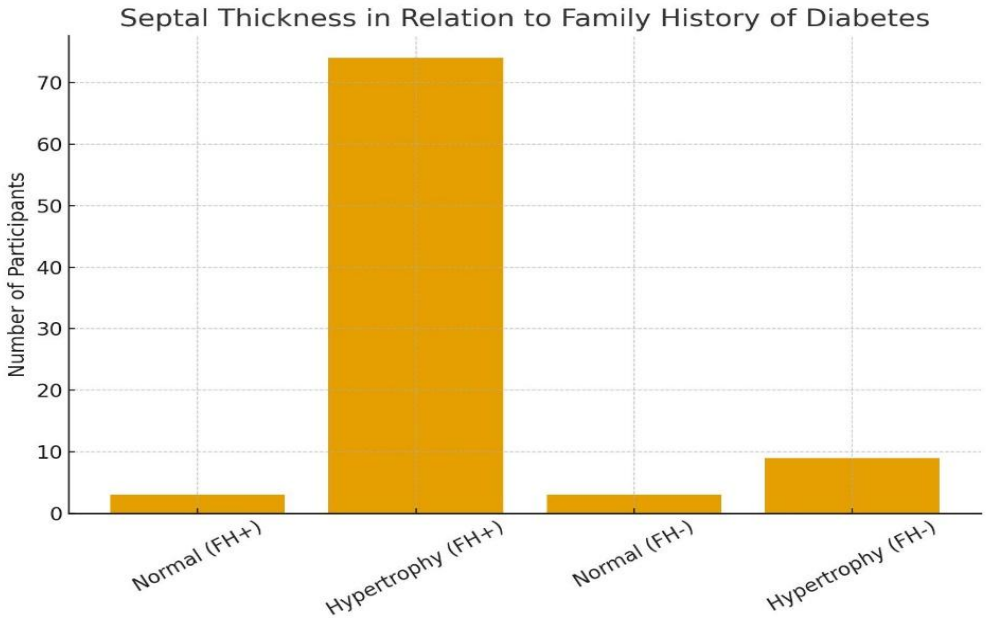

Figure 1 Septal Thickness in Relation to Family History of Diabetes

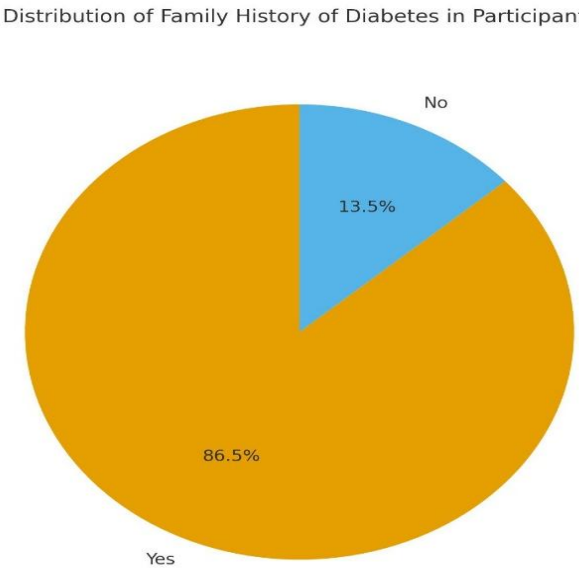

Figure 2 Distribution of Family History of Diabetes in Participants

DISCUSSION

The findings of this study demonstrated that gestational diabetes mellitus, particularly when accompanied by a family history of diabetes, was significantly associated with structural cardiac alterations in the fetus. The most notable abnormalities were septal hypertrophy and reduced left ventricular diastolic diameter, highlighting the potential role of genetic predisposition in amplifying the adverse myocardial effects of maternal hyperglycemia. These results corroborated earlier research that identified fetal myocardial dysfunction and structural remodeling in pregnancies complicated by GDM, yet the additional impact of a positive family history appeared to present a distinctive risk factor that had not been widely emphasized in prior literature (15,16). The preservation of systolic function parameters such as ejection fraction and fractional shortening in the present study was consistent with reports that found limited or inconsistent involvement of systolic function in GDM pregnancies (17). This suggests that diastolic and structural abnormalities may precede overt systolic dysfunction in fetuses exposed to maternal hyperglycemia. Importantly, the high prevalence of septal hypertrophy observed in this study reflected the pathophysiological influence of fetal hyperinsulinemia, supporting the view that maternal metabolic imbalance exerts significant stress on fetal myocardial development. The persistence of GDM-related myocardial changes into infancy and childhood has been highlighted by other studies, raising concerns about the long-term cardiovascular consequences of these in utero alterations (18,19). While the present study was restricted to prenatal evaluation, the demonstrated association between family history and myocardial remodeling indicated that such fetuses may represent a high-risk subgroup requiring closer follow-up after birth. Moreover, although congenital heart defects have been more frequently reported in GDM and pregestational diabetes in some investigations (20), no major structural defects beyond myocardial hypertrophy and LVDd changes were observed in this cohort. This difference may be related to the relatively small sample size, exclusion of pregestational diabetes, or variations in population genetics.

The strengths of the study included the use of detailed fetal echocardiography with multiple imaging planes and Doppler assessment, which allowed systematic evaluation of myocardial thickness and cardiac dimensions. Furthermore, the study addressed a critical gap in local literature by examining the combined influence of GDM and family history of diabetes, a factor rarely considered in similar investigations. However, limitations must be acknowledged. The use of purposive sampling and a relatively small sample size limited the generalizability of findings, and the short study duration constrained longitudinal assessment. Additionally, the absence of postnatal follow-up restricted the ability to establish whether the observed changes persisted beyond gestation. Parameters such as Doppler flow dynamics and septal integrity, though mentioned in the methodology, were not comprehensively reported in the results, leaving potential areas of interest unexplored. Overall, the study emphasized the importance of considering both metabolic and genetic predispositions when evaluating the impact of GDM on fetal cardiac development. The findings underscored the need for enhanced prenatal surveillance

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of women with GDM and a positive family history of diabetes, with an emphasis on early detection of myocardial changes. Future studies with larger sample sizes, longer follow-up periods, and inclusion of postnatal outcomes are warranted to clarify the long-term implications of these prenatal alterations and to guide preventive strategies aimed at improving cardiovascular health in this vulnerable population (21).

CONCLUSION

This study concluded that gestational diabetes, when coupled with a positive family history of diabetes, has a pronounced influence on fetal cardiac morphology, with notable alterations in myocardial structure such as septal hypertrophy and reduced diastolic dimensions. In contrast, systolic function remained largely preserved, highlighting that the earliest and most significant impact lies in structural rather than functional compromise. These findings underscore the importance of recognizing genetic predisposition as an additional risk factor in pregnancies complicated by gestational diabetes, reinforcing the need for enhanced prenatal surveillance and timely echocardiographic assessment to safeguard long-term cardiovascular health in the offspring.

AUTHOR CONTRIBUTION

Author	Contribution
Balqees Afzaal	Substantial Contribution to study design, analysis, acquisition of Data Manuscript Writing Has given Final Approval of the version to be published
Abdul Hakeem	Substantial Contribution to study design, acquisition and interpretation of Data Critical Review and Manuscript Writing Has given Final Approval of the version to be published
Laiba Naveed	Substantial Contribution to acquisition and interpretation of Data Has given Final Approval of the version to be published
Maheen Mirza*	Contributed to Data Collection and Analysis Has given Final Approval of the version to be published
Mahnam Ali	Contributed to Data Collection and Analysis Has given Final Approval of the version to be published
Anooshay Hania	Substantial Contribution to study design and Data Analysis Has given Final Approval of the version to be published
Huda Mohammad Nadim	Contributed to study concept and Data collection Has given Final Approval of the version to be published

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