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Epicardial fat thickness among neonates of diabetic mothers attending the neonatal intensive care unit at Fayoum University Hospital: a case control study

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Abstract

Background Using conventional echocardiography, this study aimed to evaluate the epicardial fat thickness (EFT) and its role in discriminating infants of diabetic mothers (IDMs) from those of non-diabetic mothers (INDMs) and to assess its prognostic role in IDMs. This case control study was conducted at the Neonatology and Cardiology Units of Pediatric Department, Fayoum University Hospital, Egypt, between February and September 2023. A total of 54 neonates were enrolled into three groups: 18 IDMs with well-controlled diabetes mellitus (DM), 18 IDMs with poorly controlled DM, and 18 INDMs.

Results The sensitivity, specificity, and cutoff of EFT were 100%, 100%, and 3.950 mm for detecting cases of IDMs and were 66.7%, 72.2%, and 5.100 mm for differentiating controlled from uncontrolled diabetic mothers, respectively. The interventricular septum in diastole (IVSd), interventricular septum in systole (IVSs), estimated pulmonary artery pressure (PAP), left ventricle (LV) Tei index, and isovolumetric relaxation time (IVRT) of LV all showed a positive correlation with EFT ($r=0.35$, 0.31, 0.41, 0.34, and 0.39; $P=0.009$, 0.025, 0.002, 0.01, and 0.003; respectively). There was a significant negative correlation between EFT and left ventricular internal dimensions in diastole (LVIDd) and left ventricular internal dimensions in systole (LVIDs) ($r=-0.44$ and 0.42, $P=0.001$ and 0.001). Regarding tissue Doppler, there was a significantly higher Tei index in group I cases compared to control (0.59 ± 0.10 vs. 0.49 ± 0.09, $P<0.001$).

Conclusions The EFT is higher in IDMs than in INDMs, with a positive correlation with birth weight, IVSd, IVSs, Tei index of mitral, IVRT, and ESPAP and a negative correlation with LVIDd and LVIDs. Neonatal EFT can be used as one of the helpful parameters to detect IDMs. Also, it may be used as one of the prognostic factors in IDMs as it is positively correlated with the diastolic function of the LV.

Keywords Infant of diabetic mother, Epicardial fat thickness, Tissue Doppler imaging

Background

Diabetes necessitates ongoing medical care and risk reduction strategies, beyond glucose management. Self-management education and support are crucial for preventing acute and long-term complications [1].

The term "gestational diabetes mellitus" (GDM) describes varied degrees of glucose intolerance that initially appears during pregnancy. The entire etiopathogenesis of the illness is still unknown. Along with obesity,

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genetics, and environmental factors, inflammatory factors leading to insulin resistance and dysfunction triggered by placental hormones play a major role in the etiopathogenesis of the disease [2].

Maternal hyperglycemia during the first trimester might result in significant birth abnormalities such truncus arteriosus or aortic coarctation or spontaneous abortions. Maternal hyperglycemia during the second and third trimesters can result in hyperglycemia and hyperinsulinemia in the fetus. These conditions can also produce hypocalcemia, polycythemia, hyperbilirubinemia, septal cardiac hypertrophy, delayed lung maturation, and macrosomia in the neonate [3].

Physicians generally advise patients to maintain optimal glycemic control prior to conception and during the first few months of pregnancy, but few people actually do so. During the organogenesis phase of pregnancy, hemoglobin A1c levels obtained in the first half of the pregnancy can serve as a marker for average blood glucose levels [4].

It has been demonstrated that fetal metabolism is impacted by maternal metabolic illness. The fetuses of mothers with diabetes exhibit modified adiposity, elevated insulin resistance, inflammation, and hematological alterations that are indicative of chronic hypoxia [5].

Echocardiography can measure the thickness of epicardial adipose tissue (EAT), an emerging cardiometabolic risk factor. It is still unclear how EAT and the metabolic syndrome are related [6].

There have been reports of asymmetrical septal hypertrophy and hypertrophic cardiomyopathy (HCM) in newborns of diabetes mothers due to the stimulation of their hearts by insulin and other growth hormones. Moreover, epicardial fat is an early contributor to the diastolic function, similar to an alteration in HCM [7].

The need for markers to predict gestational diabetes mellitus (GDM) and its associated perinatal complications is growing, with fetal adipose tissue increase most frequently in the third trimester [8]. Therefore, the aim of this study was to evaluate epicardial fat thickness and its role in discriminating infants of diabetic mothers from those of non-diabetic mothers and to assess its prognostic role in these infants.

Methods

This case control study was conducted in the Neonatology and Cardiology Units of the Pediatric Department at El-Fayoum University Hospital, Fayoum, Egypt, from February to September 2023. The study included 54 neonates, who were divided into three groups: Group I, cases group included 18 neonates of well-controlled diabetic mothers (glycosylated hemoglobin [HbA1c] less than 7); Group II, cases group included 18 neonates of poorly controlled diabetic mothers (HbA1c greater than 7); and Group III, control group. This group included 18 neonates of healthy, non-diabetic mothers. The study groups were matched for sex and age. The inclusion criteria for participation in the study were neonates of diabetic and non-diabetic mothers of both sexes. Neonates with suspected chromosomal abnormalities were excluded from the study.

All the neonates underwent the following procedure:

1. Detailed history taking including gestational age, mode of delivery, maternal type of diabetes, history of neonatal intensive care unit (NICU) admission, history of jaundice, maternal illness other than diabetes, and history of respiratory distress.
2. Clinical assessment of the patient encompassing vital signs, recumbent length, weight, and head circumfer-

Table 1 Comparisons of demographic characteristics and anthropometric measures in different study groups

Variables	Group I (*N* = 18)	Group II (*N* = 18)	Group III (*N* = 18)	*P* value
Age (days)				
Mean ± SD	5.78 ± 0.81	6.06 ± 1.1	6.28 ± 0.83	0.27
Sex				
Female	7 (38.9%)	12 (66.7%)	6 (33.3%)	0.09
Male	11 (61.1%)	6 (33.3%)	12 (66.7%)	
Mode of delivery				
Vaginal	1 (5.6%)	1 (5.6%)	2 (11.1%)	0.76
Caesarean section	17 (94.4%)	17 (94.4%)	16 (88.9%)	
Gestational age (weeks)	37.9 ± 0.83	38.1 ± 0.64	38.5 ± 0.92	0.11
Birth weight (Grams)	3444.4 ± 197.7	3502.8 ± 239.2	3058.3 ± 175.9	0.99 a < 0.001 b,c*
Recumbent length (cm)	49.9 ± 1.2	49.7 ± 1.3	49.6 ± 1.1	0.81
Head circumference (cm)	35.2 ± 0.92	35.2 ± 0.94	35 ± 0.62	0.75

Group I: neonates of well-controlled diabetic mothers. Group II: neonates of poorly controlled diabetic mothers. Group III: neonates of healthy, non-diabetic mothers; *SD* standard deviation; *a, significance difference between Group Is and II; *b, significance difference between Groups I and III; *c, significance difference between Groups II and III

ence in addition to a comprehensive general assessment (including any dysmorphic features). Additionally, neurological, cardiac, abdominal, and chest exams were carried out.

3. Investigations:
   - Laboratory investigations that prove the glycemic state of mothers of IDMs, including HBA1c.
   - Imaging investigations, including echocardiography (conventional echocardiography) and tissue Doppler imaging (TDI), were conducted within the first week of life. A General Electric Vivid 5-color Doppler ultrasound system with transducers operating at 3.75 MHz or 5 MHz, appropriate for infants, was used to perform echocardiography.

Table 2 Comparisons of demographic characters in different cases groups

Variables	Group I (*N* = 18)	Group II (*N* = 18)	*P* value
Mean ± SD			
HBA1c (%)	6.37 ± 0.67	7.73 ± 0.74	< 0.001*
Type of maternal diabetes			
Type 1	0 (0%)	1 (5.6%)	0.14
Type 2	2 (11.1%)	6 (33.3%)	
Gestational	16 (88.9%)	11 (61.1%)	

Group I: neonates of well-controlled diabetic mothers. Group II: neonates of poorly controlled diabetic mothers; *SD* standard deviation, *HbA1c* glycosylated hemoglobin; *significant

A complete echocardiographic examination was performed. Using conventional echocardiography from the standard transthoracic windows: Parasternal long axis Transducer in cardiac M mode, left ventricular end diastolic diameter (LVEDD), LV end systolic diameter (LVESD), LV posterior wall (LVPW), and LV ejection fraction (EF) were measured [9].

- Using pulsed wave Doppler imaging and transmitral E wave velocity (E) and (A) wave velocity were averaged to generate the mean value, and this was done by apical 4 chamber view on the mitral septal leaflet [9]. Myocardial velocity in systole, early diastole, and late diastole was measured using the TDI. The Tei index, also known as the global myocardial performance index, was calculated using tissue Doppler and pulsed tissue velocity imaging. By dividing the total isovolumic contraction and relaxation times by the ejection time, it can be defined [10].

The region between the visceral layer of the pericardium and the outer wall of the myocardium that is echo-free has been named epicardial fat thickness (EFT). Using the aortic annulus as the anatomical landmark, the EFT was measured in the parasternal long axis view perpendicular to it [11].

All measurements were taken end systolic when the EFT was highest. The average value of three cardiac cycles was calculated.

Table 3 Comparisons of medical history in different study groups

Variables	Group I (*N* = 18) No. (%)	Group II (*N* = 18) No. (%)	Group III (*N* = 18) No. (%)	*P* value
NICU admission				
No	9 (50%)	7 (38.9%)	12 (66.7%)	0.24
Yes	9 (50%)	11 (61.1%)	6 (33.3%)	
History of jaundice				
No	3 (16.7%)	3 (16.7%)	6 (33.3%)	0.38
Yes	15 (83.3%)	15 (83.3%)	12 (66.7%)	
History of respiratory distress				
No	16 (88.9%)	11 (61.1%)	16 (88.9%)	0.06
Yes	2 (11.1%)	7 (38.9%)	2 (11.1%)	
Type of oxygen support				
No	16 (88.9%)	11 (61.1%)	16 (88.9%)	0.13
Nasal O_2	1 (5.6%)	6 (33.3%)	2 (11.1%)	
CPAP	1 (5.6%)	0 (0%)	0 (0%)	
Mechanical ventilation	0 (0%)	1 (5.6%)	0 (0%)	
Maternal illness				
No	15 (83.3%)	17 (94.4%)	18 (100%)	0.15
Yes	3 (16.7%)	1 (5.6%)	0 (0%)	

Group I: neonates of well-controlled diabetic mothers. Group II: neonates of poorly controlled diabetic mothers. Group III: neonates of healthy, non-diabetic mothers; *NICU* neonatal intensive care unit, *CPAP* continuous positive airway pressure

Statistical methods

In order to make the manipulation easier, data were gathered and coded. After that, Microsoft Access was used to enter and analyze the data. The statistical package for the social sciences (SPSS) version 22 program was used to analyze the data on a Windows 7 computer (SPSS Inc., Chicago, IL, USA). The qualitative data were presented as numbers and percentages for a basic descriptive analysis, while the quantitative parametric data were summarized using standard deviations as measures of dispersion and arithmetic means as measures of central tendency. An independent sample *t*-test was employed in the analysis of quantitative data to compare quantitative measures between the two independent groups. The chi-square test was utilized to compare two or more qualitative groups in order to analyze the qualitative data. To examine the relationship between the variables, bivariate Pearson's correlation tests were performed. Receiver operating characteristic (ROC) curves were used in sensitivity and specificity tests to evaluate the efficacy of a new test. At $P < 0.05$, statistical significance was established.

Ethics approval and consent to participate

This study was reviewed by the Ethics Committee of the Faculty of Medicine (Approval ID: M642). The study was performed in accordance with the ethical standards as laid down in the 1964 Declaration of Helsinki and its later amendments or comparable ethical standards. Informed consents were obtained from the participants' legal guardians.

Table 4 Comparisons of conventional Echocardiographic findings and tissue Doppler finding in different study groups

Variables	Group I (*N* = 18) Mean ± SD	Group II (*N* = 18) Mean ± SD	Group III (*N* = 18) Mean ± SD	*P* value
IVSd (cm)	0.66 ± 0.18	0.65 ± 0.12	0.53 ± 0.06	0.9 a 0.009 b* 0.03 c*
IVSs (cm)	0.77 ± 0.12	0.76 ± 0.15	0.64 ± 0.11	0.9 a 0.01 b* 0.03 c*
LVIDd (cm)	1.4 ± 0.24	1.38 ± 0.23	1.78 ± 0.34	0.9 a < 0.001 b,c*
LVIDs (cm)	0.87 ± 0.18	0.91 ± 0.14	1.07 ± 0.17	0.09 a 0.001 b* 0.01 c*
LVPWd (cm)	0.49 ± 0.12	0.48 ± 0.09	0.48 ± 0.04	0.94
LVPWs (cm)	0.61 ± 0.13	0.59 ± 0.11	0.62 ± 0.11	0.81
EF (%)	71 ± 6.9	69.9 ± 7.9	69.5 ± 6.3	0.80
FS (%)	37.7 ± 6.3	36.6 ± 6.7	36.5 ± 4.9	0.79
TAPSE (mm)	11.33 ± 2.1	10.94 ± 1.9	11.83 ± 0.98	0.31
LA diameter (mm)	10.83 ± 1.5	11.44 ± 2 .2	11.61 ± 1.6	0.39
AR diameter (mm)	10.78 ± 1.3	11.22 ± 1.6	11.44 ± 0.98	0.30
LA/AR ratio	1 ± 0.10	1 ± 0.12	1 ± 0.09	0.99
EA ratio	1.13 ± 0.26	1.20 ± 0.27	1.21 ± 0.21	0.61
ESPAP (mmHg)	31.22 ± 10.1	34.67 ± 11.1	26.11 ± 3.7	0.75 a 0.27 b 0.01 c*
IVCT mitral (ms)	36.33 ± 8.1	37.56 ± .8	35.33 ± 7.9	0.70
IVRT mitral (ms)	42.7 ± 10.3	43 ± 9.9	36.7 ± 7.5	0.08
ET mitral (ms)	134.6 ± 21.9	139.1 ± 21.5	147.2 ± 26.3	0.26
Tie of mitral (ms)	0.59 ± 0.10	0.56 ± 0.11	0.49 ± 0.09	0.9 a 0.02 b* 0.17 c

Group I: neonates of well-controlled diabetic mothers. Group II: neonates of poorly controlled diabetic mothers. Group III: neonates of healthy, non-diabetic mothers; *SD* standard deviation, *a, significance difference between Groups I and II; *b, significance difference between Groups I and III; *c, significance difference between Groups II and III; *IVSd* interventricular septum (diastole), *IVSs* interventricular septum (systole), *LVIDd* left ventricular internal dimensions (diastole), *LVIDs* left ventricular internal dimensions (systole), *LVPWd* left ventricular posterior wall (diastole), *LVPWs* left ventricular posterior wall in systole, *EF* ejection fraction, *FS* fraction shortening, *TAPSE* tricuspid annular plane systolic excursion, *LA* left atrium, *AR* aortic root, *EA* E wave/A wave, *ESPAP* estimated pulmonary artery pressure, *IVCT* isovolumic contraction time, *IVRT* isovolumetric relaxation time, *ET* ejection time

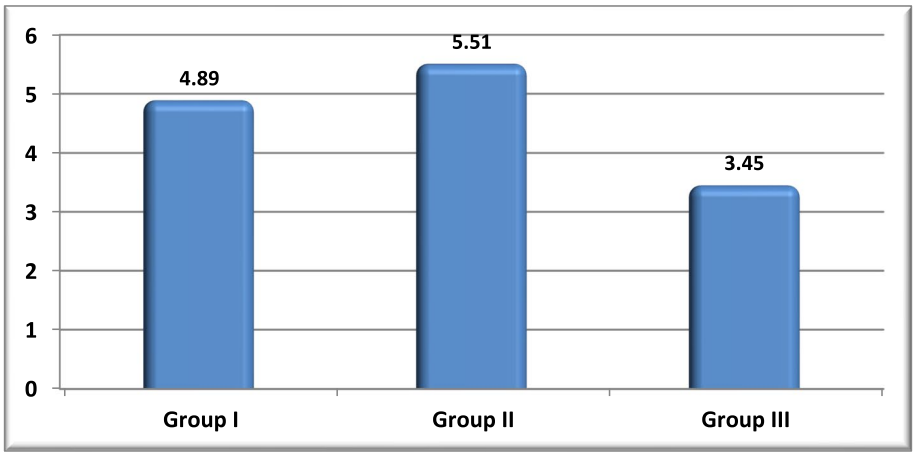

Fig. 1 Mean epicardial fat thickness in the study groups

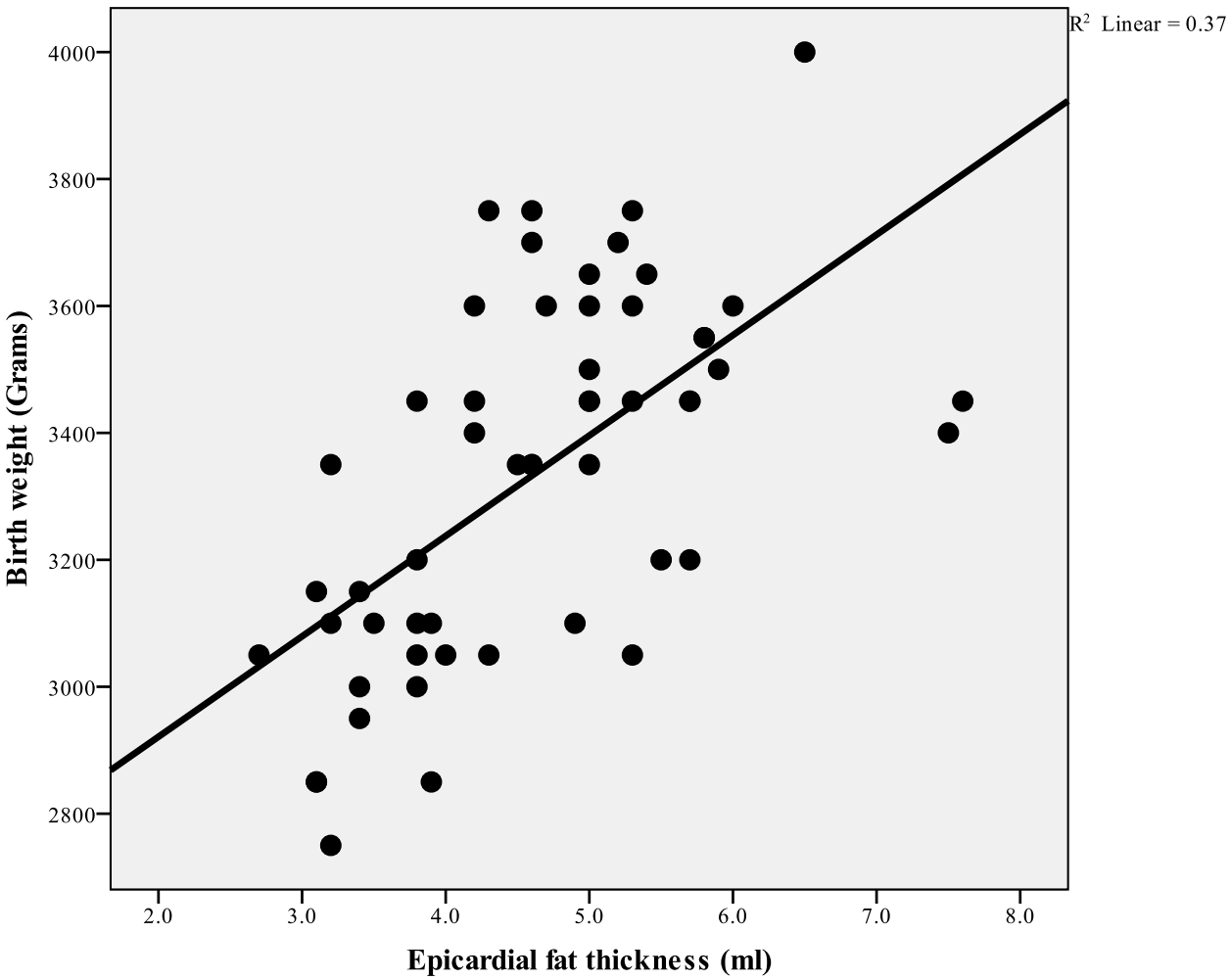

Fig. 2 Correlation between epicardial fat thickness and birth weight

Results

We recruited 54 neonates who were divided into 3 groups: 18 neonates with IDMs with well controlled DM (HbA1c less than 7), 18 neonates of IDMs with poorly controlled DM (HbA1c greater than 7), and 18 healthy neonates of non-diabetic mothers. This case control study was conducted at the Neonatal and Cardiology Units of the Pediatric Department at Fayoum University Hospital, Fayoum, Egypt, between February and September 2023.

Our findings indicated that there was no statistically significant difference in mode of delivery or gestational age between cases and controls. As regards anthropometric measures, there was a statistically significant higher birth weight in both groups of cases when compared with the control (Table 1).

The mean of HBA1c in IDMs with well controlled DM was 6.37 ± 0.67; on the other hand, the mean of HBA1c in IDMs with poorly controlled DM was 7.73 ± 0.74, which is significantly different. There was no statistically significant difference with a $P > 0.05$ as regards types of diabetes (Table 2).

As regards medical history among study groups, there was no statistically significant difference with a P value < 0.05 (Table 3).

In terms of echocardiographic findings, there was a statistically significant difference in IVSd, IVSs, LVIDd, and LVIDs levels between group I and group III and between groups II and III with a $P < 0.05$. As regards ESPAP level, there was a statistically significant difference with a P value of 0.01 between groups II and III, with a higher mean among group II. As regards the tissue Doppler finding, there was a statistically significant higher level of Tei of LV among group I in comparison to group III with a P value of 0.02 (Table 4).

In terms of EFT, the mean was higher among group II, followed by group I, and the lowest level was in group III, which is statistically significant (Fig. 1).

Between EFT and neonatal birth weight, there was a statistically significant positive correlation (P value < 0.05) ($r = 0.61$, $P = 0.001$) (Fig. 2).

There was a statistically significant positive correlation with a P value < 0.05 between EFT and each of IVSd ($r = 0.35$, $P = 0.009$), IVSs ($r = 0.31$, $P = 0.025$), and ESPAP ($r = 0.41$, $P = 0.002$) measurements, and a significant negative correlation with LVIDd and LVIDs measurements. Additionally, a statistically significant correlation (P value < 0.05) was found between the EFT and Tei index of LV ($r = 0.34$, $P = 0.01$) and IVRT ($r = 0$ 0.39, $P = 0.03$) (Table 5).

The sensitivity and specificity tests for EFT in the diagnosis of cases of diabetic mothers were 100% at a cutoff value of 3.950 mm, and for differentiation between controlled and uncontrolled diabetic mothers, the sensitivity was 66.7%, and the specificity was 72.2% at a cutoff value of 5.100 mm (Figs. 3 and 4).

Table 5 Correlation between epicardial fat thickness and echo findings in different study groups

Variables	Epicardial fat thickness	
	R	*P* value
IVSD (cm)	0.35	0.009*
IVSs (cm)	0.31	0.025*
LVIDd (cm)	− 0.44	0.001*
LVIDs (cm)	− 0.42	0.001*
LVPWd (cm)	0.18	0.18
LVPWs (cm)	0.17	0.19
EF (%)	0.16	0.24
FS (%)	0.17	0.21
TAPSE (ml)	− 0.08	0.54
LA diameter (ml)	0.08	0.56
AR diameter (ml)	0.06	0.66
LA/AO root ratio	0.08	0.57
EA ratio	− 0.03	0.83
ESPAP (mmHg)	0.41	0.002
IVCT mitral (ms)	0.24	0.08
IVRT mitral (ms)	0.39	0.003*
ET mitral (ms)	− 0.10	0.45
Tie of mitral (ms)	0.34	0.01*

IVSd interventricular septum (diastole), *IVSs* interventricular septum (systole), *LVIDd* left ventricular internal dimensions (diastole), *LVIDs* left ventricular internal dimensions (systole), *LVPWd* left ventricular posterior wall (diastole), *LVPWs* left ventricular posterior wall (systole), *EF* ejection fraction, *FS* fraction shortening, *TAPSE* tricuspid annular plane systolic excursion, *LA* left atrium, *AR* aortic root, *EA* E wave/A wave, *ESPAP* estimated pulmonary artery pressure, *IVCT* isovolumic contraction time, *IVRT* isovolumetric relaxation time, *ET* ejection time; *significant

Discussion

EFT has emerged as a new marker of cardiometabolic risk due to its intimate proximity with the myocardium, the coronary arteries, and its endocrine metabolic features [6].

The large visceral fat storage known as EFT is situated around the large coronary arteries and between the epicardium and pericardium. Through the cytokine pathway, this tissue contributes to the development of atherosclerosis and has significant endocrine and paracrine activity [12].

Maternal diabetes modifies the fetal environment, which causes more and earlier fat deposition in the epicardial fat compared to other fat stores [8].

In the current study, we found that IDMs have LV hypertrophy. They also have global myocardial dysfunction in comparison to healthy individuals using two dimensional conventional echocardiography and TDI. These findings are consistent with those reported by

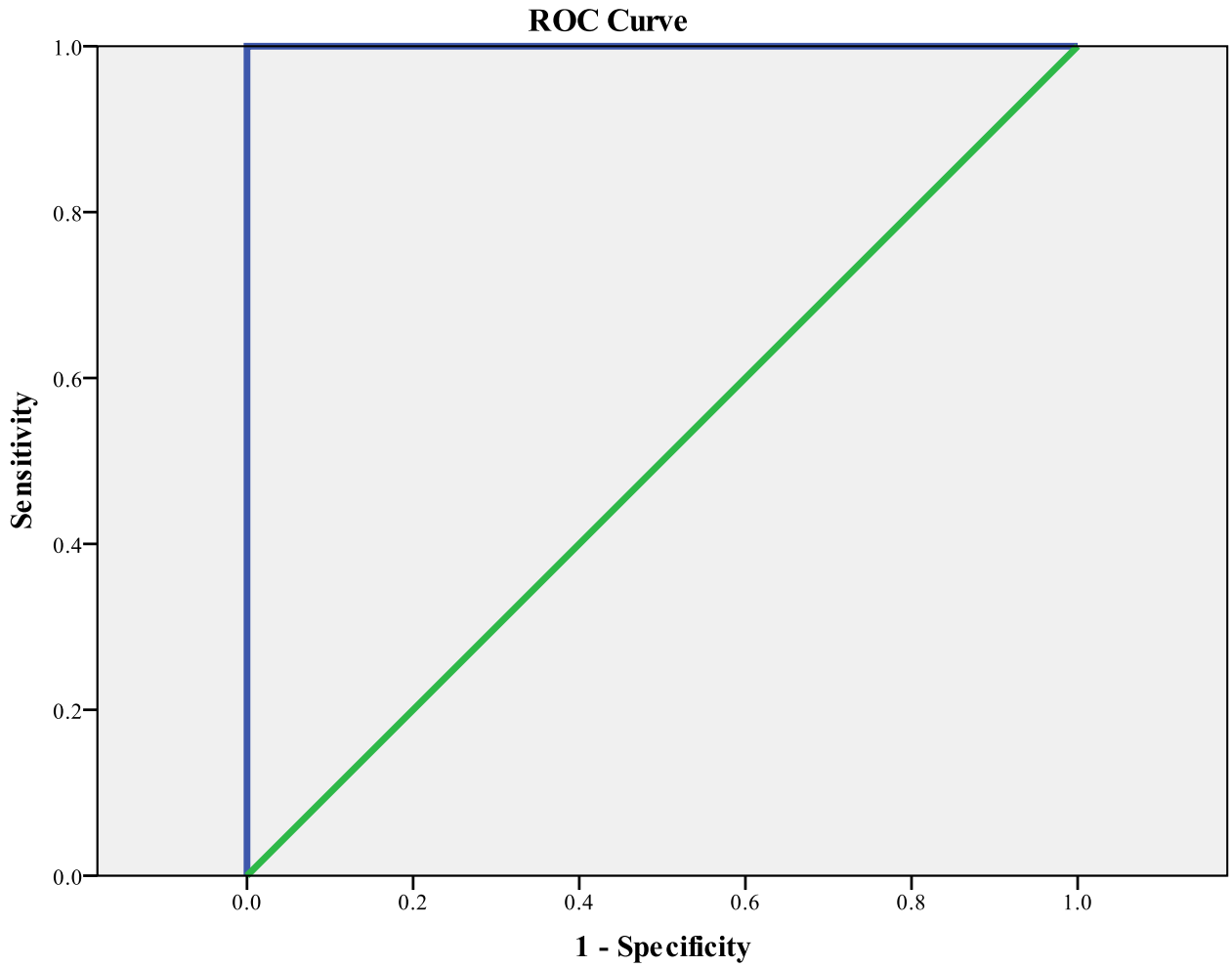

Fig. 3 Receiver operating characteristic curve for epicardial fat thickness in diagnosis of diabetic cases

Farag et al. [13]. We found that IDM with poorly controlled diabetes has a significantly higher ESPAP in comparison to healthy individuals.

Chronic fetal hyperinsulinemia causes fetal macrosomia and increases the cardiac mass due to a larger mass of myocardial nuclei, an increase in the number of myocardial cells, and hypertrophy of myocardial fibers. There are more insulin receptors in the fetal heart, which makes it easier for protein and fat synthesis regardless of how much glycogen is deposited, which makes IDM more susceptible to HCM and increased LV dimensions [14].

We found that there was a statistically significant difference between study groups as regards EFT, with a higher mean among IDM patients with poorly controlled diabetes. It is followed by IDM with well controlled diabetes, and the lowest level was in healthy control. These findings agree with those of Vela-Huerta et al. [9] who reported the same findings. The altered fetal environment, including hyperinsulinemia and hyperglycemia resulting from maternal diabetes, results in greater and earlier fat deposition in epicardial fat than in other fat stores [8].

In the current study, EFT was positively correlated with neonatal birth weight. Similar to our findings, Jackson et al. [15] reported that in the fetuses of diabetic mothers, EFT correlates directly with both EFW and abdominal circumference. Both of these are previously validated sonographic markers of an adverse fetal response to the diabetic state.

The presence of hyperglycemia, hyperinsulinemia, and inflammatory processes enhances the placental supply of nutrients to the developing fetus, including not only glucose but also amino acids and free fatty acids, thereby exerting an impact on fetal growth, causing macrosomia, and fat deposition in the epicardial space, resulting in higher EFT [16].

Our study also showed that there was a statistically significant positive correlation between EFT and each

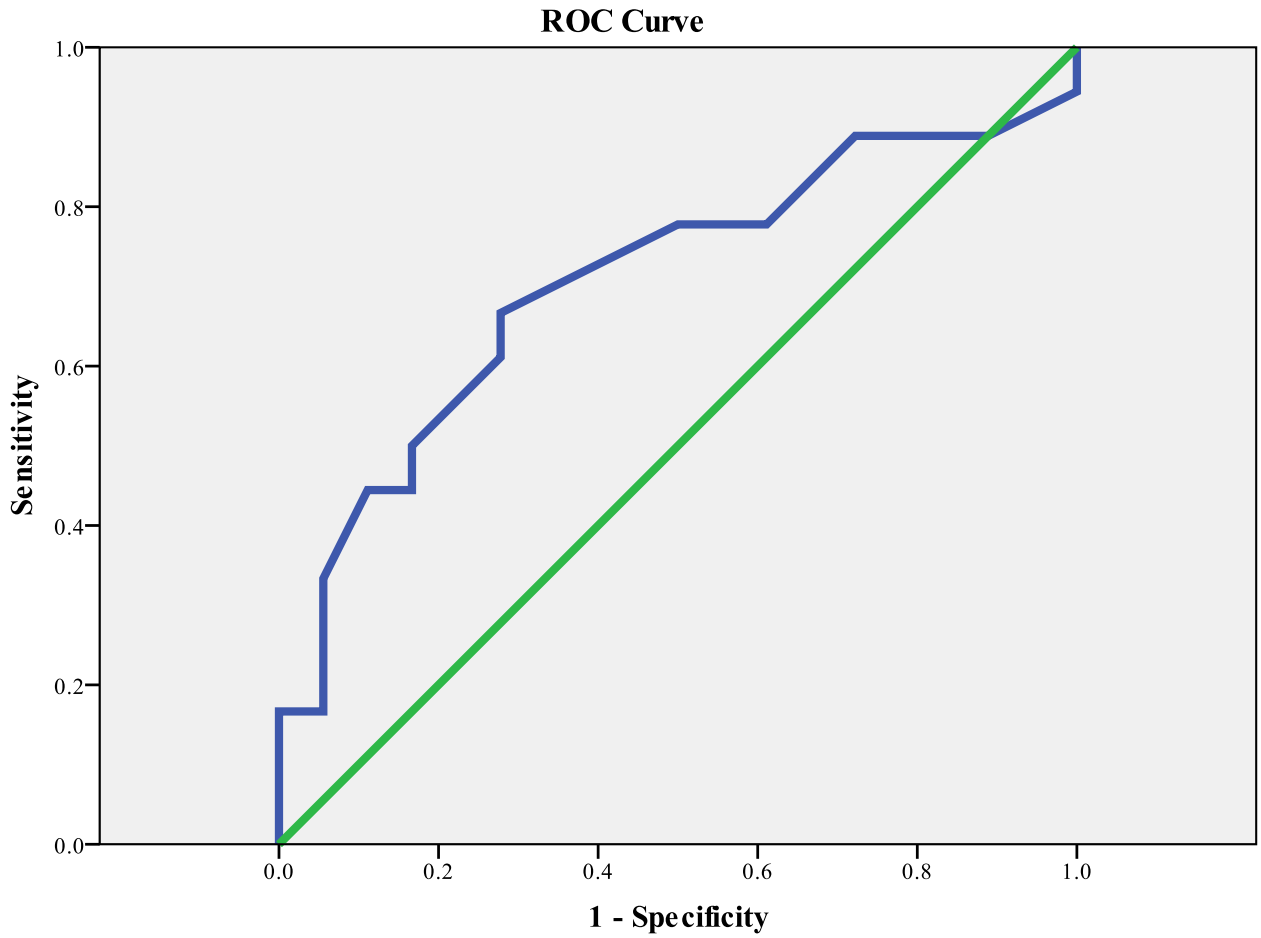

Fig. 4 Receiver operating characteristic curve for epicardial fat thickness in diagnosis of controlled and uncontrolled diabetic cases

of the IVSd, IVSs, and ESPAP measurements and a significant negative correlation with the LVIDd and LVIDs measurements. This agrees with the results reported by Vela-Huerta et al. [9].

Hypertrophic cardiomyopathy is a prevalent cardiac anomaly observed in around 40% of pregnancies affected by diabetes. Myocardial hypertrophy is distinguished by the augmentation of both the interventricular septum and ventricular walls [17] caused by an altered fetal environment regarding hyperglycemia and hyperinsulinemia, which are similar mechanisms attributed to higher EFT found in IDM [9].

Our study illustrated that there was a statistically significant positive correlation between EFT, each of IVRT, and Tei of LV. Similar to our findings, Ghandi et al. [18] found that there was a statistically higher incidence of diastolic dysfunction in cases of IDMs than in the healthy control group.

Underdeveloped fetal ventricular compliance and, as a result, diastolic dysfunction because of a thicker cardiac wall occurs in IDMS [19]. Increased epicardial fat mechanically affects LV and RV diastolic filling, causing diastolic dysfunction [11].

We found that the sensitivity and specificity test for EFT in the detection of cases of diabetic mothers was 100% at a cutoff value of 3.950 mm, and for differentiation between controlled and uncontrolled diabetic mothers, the sensitivity was 66.7% and the specificity was 72.2 at a cutoff value of 5.100 mm.

The main reason for EFT to be a reliable marker is that it is not affected by changes in subcutaneous and muscle tissues [20]. The altered fetal environment, including hyperinsulinemia and hyperglycemia resulting from maternal diabetes, results in greater and earlier fat deposition in epicardial fat than in other fat stores [8].

The limitations of the present study were the need for further studies with larger number of patients, and the

need for long-term follow-up period to understand the etiology and clinical implications of the echocardiographic findings.

Conclusions

We concluded that the sensitivity and specificity tests for EFT in the detection of cases of diabetic mothers were 100% at a cutoff value of 3.950 mm, and for the differentiation of controlled from uncontrolled diabetic mothers, the sensitivity was 66.7% and the specificity was 72.2% at a cutoff value of 5.100 mm. EFT increases more in infants with elevated IVSd, IVSs, ESPAP, IVRT, and Tei index of mitral. There is a significant negative correlation with LVIDd and LVIDs measurements. Neonatal EFT can be used as one of the helpful parameters to detect IDMs. Also, it may be used as one of the prognostic factors in IDM as it is positively correlated with the diastolic function of the LV, so these neonates should be monitored closely.

Abbreviations

A	A wave
AO	Aortic root
BW	Birth weight
E	E wave
EAT	Epicardial adipose tissue
EF	Ejection fraction
EFT	Epicardial fat thickness
ESPAP	Estimated pulmonary artery pressure
ET	Ejection time
FS	Fraction shortening
GDM	Gestational diabetes mellitus
HbA1c	Glycosylated hemoglobin
HCM	Hypertrophic cardiomyopathy
IDMs	Infants of diabetic mothers
INDMs	Infants of non-diabetic mothers
IVCT	Isovolumic contraction time
IVRT	Isovolumic relaxation time
IVSd	Interventricular septum in diastole
IVSs	Interventricular septum in systole
LVIDd	Left ventricular internal dimensions in diastole
LVIDs	Left ventricular internal dimensions in systole
LVPW	Left ventricular posterior wall
MPI or Tei	Myocardial performance index
TAPSE	Tricuspid annular plane systolic excursion

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Not applicable

Authors' contributions

AA, RY, AS, and HB have full access to all the data in the study and take responsibility for the integrity of the data. Study concept and design: AA and HB. Acquisition of data: RY and AS. Analysis of data: HB and AA. Drafting of the manuscript: RY and AS. Critical revision of the manuscript: AA and HB. All authors have read and approved the final manuscript.

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Availability of data and materials

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Declarations

Ethics approval and consent to participate

This study was reviewed by the Ethics Committee of the Faculty of Medicine, Fayoum University, Egypt (Approval ID: M642). The study was performed in accordance with the ethical standards as laid down in the 1964 Declaration of Helsinki and its later amendments or comparable ethical standards. Informed consents were obtained from the participants' legal guardians.

Consent for publication

Not applicable.

Competing interests

The authors declare that they have no competing interests.

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