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EVALUATION OF FETAL CARDIAC FUNCTION BY FETAL ECHOCARDIOGRAPHY IN PREGNANT DIABETIC PATIENTS

By

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ABSTRACT

Background: Epidemiological studies have shown that children of women with gestational diabetes have increased risk to develop early cardiovascular disease in childhood and young adulthood. GDM is associated with fetal cardiac morphological and functional changes which are mostly noted in the right ventricle, which is consistent with the dominance of the right heart late in gestation.

Objective: To evaluate fetal cardiac function by fetal echocardiography in pregnant diabetic patients including assessment of systolic function, diastolic function and their alteration in pregnant diabetic patients.

Patients and methods: This study was a prospective study that conducted on a total of 80 patients who attended outpatient clinics at Obstetrics and Gynecology Department, Al-Azhar University Hospitals during the period from May 2020 till May 2021. All cases had gestational age above 28 weeks, and all suffered from GDM. We measured the glycosylated hemoglobin (HbA1c) levels of the participants; the mean cut off value was 6.5%, where a level of < 6.5% indicates good glycemic control and a level of > 6.5% indicates poor glycemic control.

Results: The mean HbA1c of pregnant women with uncontrolled diabetes was significantly higher than that detected in controlled women with diabetes (6.84±0.52 % vs. 5.27±0.29 %, P<0.001). The mean age of pregnant women with controlled and uncontrolled diabetes was 26.9±3.44 and 25.62±3.96 years respectively. There were no statistically significant differences between the two groups regarding age (P=0.128). There were 17 women with controlled diabetes (42.5%) and twenty women with uncontrolled diabetes (50%) had their age ranged between (18-25) years. As regard echocardiographic assessment, measurement of ventricular myocardial free walls and interventricular septal thickness was done as a tool for evaluation of cardiac hypertrophic cardiomyopathy that occurs in fetuses of diabetic mothers. Doppler-derived modified myocardial performance index (Mod-MPI) was used to assess global overall systolic and diastolic function to display whether impairment of fetal cardiac function occurred or not. Both groups were within a comparable gestational age (between 28 and 38 weeks gestation).

Conclusion: Uncontrolled gestational diabetes mellitus in pregnant women can cause changes such as in the thickness of the ventricular wall of the fetus's heart, and cardiac diastolic dysfunction especially prolonged IVRT, which can have more severe consequences.

Keywords: Fetal Cardiac Function, Fetal Echocardiography, Pregnant Diabetic Patient.

INTRODUCTION

Gestational diabetes mellitus (GDM) is defined as carbohydrate intolerance recognized for the first time during pregnancy and usually resolves after delivery. The outcome of gestational diabetes is good especially with controlled blood glucose levels. However, GDM increases the risk of a number of fetal adverse outcomes. Fetuses of diabetic mothers are prone to fetal hyperglycemia and hyperinsulinism secondary to maternal hyperglycemia *(Raafat et al., 2020)*.

Maternal diabetes is associated with increased risk of fetal morbidity, stillbirth, and neonatal morbidity and mortality; hyperglycemia and hyperinsulinemia and high content of insulin receptors lead to increase in growth factors, hyperplasia, and hypertrophy of the myocardium of the fetal heart; diastolic dysfunction is the earliest changes preceding systolic dysfunction *(Bayoumy et al., 2020)*.

Exposure to a diabetic intrauterine environment has long been recognized as a risk to the fetus, with a double impact on the fetal heart. During embryogenesis it has a teratogenic effect, increasing the incidence of structural cardiac anomalies. More commonly, infant of mothers with diabetes are at higher risk for developing fetal hypertrophic cardiomyopathy *(Miranda et al., 2018)*. Fetal Doppler echocardiogram has been used as a non-invasive test in the diagnosis of morphological and functional changes in the fetal and pediatric heart *(Bogo et al., 2020)*.

Approximately, 3-6% of infants of diabetic mothers (IDMs) have congenital cardiac malformations. While 40% of infants of diabetic mothers have hypertrophic cardiomyopathy (HCM) that may or may not be symptomatic. A major finding is hypertrophy of the ventricular and sepal walls of the neonatal heart. In all, 5% of neonates born to diabetic mothers suffer from congestive heart failure due to left ventricular outflow obstruction. Fortunately, in most cases, cardiac hypertrophy is transient with spontaneous echocardiographic resolution within the early months after birth, requiring no therapy *(Nasr Addeen et al., 2018)*.

Echocardiography is routinely indicated for fetuses of diabetic women. However, metabolic expression occurs fully from the 24th week onwards. Fetal echocardiography is often carried out in diabetic mothers because of increased risk of structural cardiovascular malformations in their fetuses. The diagnostic yield however is low. Structural cardiovascular malformations are uncommon, however, changes in cardiovascular flow patterns in fetuses of diabetic mothers may have prognostic significance *(Pilania et al., 2016)*.

It remains unknown whether these cardiac changes in response to a relative mild and transient maternal disease persist in postnatal life and whether they identify the subgroup of children who are at increased long-term cardiovascular risk *(Aguilera et al., 2021)*. Fetal cardiac function analysis may provide important information on the hemodynamic status and on the cardiovascular adaptation for different perinatal adverse effects *(Garcia-Flores et al., 2011)*.

The aim of the present study was to evaluate fetal cardiac function by fetal

echocardiography in pregnant diabetic patients including assessment of systolic function, diastolic function and their alteration in pregnant diabetic patients.

PATIENTS AND METHODS

This was a prospective study that conducted on a total of 80 patients who attended outpatient clinics at Obstetrics and Gynecology Department, Al-Azhar University Hospitals during the period from May 2020 till May 2021.

Approval of ethical committee was obtained from quality education assurance unit, Al-Azhar University Faculty of Medicine, Egypt. Verbal consent was taken from every patient and control before participation in this study.

Sample size justification:

Sample sizes was 80 cases divided into two equal groups: Group I: with controlled diabetes, and Group II: with uncontrolled diabetes.

Inclusion criteria:

- Singleton pregnancies.
- No major malformations.
- Gestational age above 28 weeks.
- Diagnosis of diabetes.

The diagnosis of diabetes was based on the criteria provided by the American Diabetes Association, that was, plasma glucose level > 92 mg/dl (fasting) and > 153 mg/dl (2 hours post prandial), (According to American Diabetes Association (ADA) 2016 Guideline): We measured the glycosylated hemoglobin (HbA1c) levels of the participants; the mean cut off value was 6.5%, where a level of < 6.5% indicates good glycemic control and a level of > 6.5% indicates poor glycemic control

Criteria of controlled diabetics:

a. Preprandial blood sugar level was 70-100 mg/dl.

b. Postprandial blood sugar level was 126-140 mg/dl.

c. Glycosylated hemoglobin (HbA1c) was < 7.

Exclusion criteria:

- Structural or chromosomal fetal anomalies.
- Fetal arrhythmias.
- Fetal growth restriction.
- Evidence of fetal infection.
- Multiple pregnancies.
- Pregnancies conceived by assisted reproductive technology.
- Maternal chronic disease other than diabetes mellitus.

All women were subjected to the following:

1. A detailed medical history which included: Personal history as age, menstrual history, date of last menstrual period (LMP) for confirming of gestational age, past history, previous operations (especially cesarean section), past obstetric history, history of drug intake, and family history.
2. Clinical examinations included:

- Measurement of weight, height and body mass index (BMI) using the formula: BMI= weight (kg)/ [height (m)]^2.

Assessment of vital signs (body temperature, pulse and blood pressure) to assess the hemodynamic status: cardiac and chest examination, and abdominal examination for assessment of estimated fetal weight, fetal movement, fetal heart sounds, fundal level and polyhydramnios.

3. Routine laboratory investigations included: CBC, liver and kidney functions, coagulation profile, fasting and postprandial blood glucose levels, glycosylated hemoglobin, and urine analysis.
4. Imaging protocol:

The ultrasound equipment used was (Mindray DC -30 China) using a 3.5- 5-MHz transabdominal probe at the ultrasound unit of the Obstetrics and Gynecology department at Al Zahraa Hospital, Al Azhar University, Egypt.

For assessment of fetal viability, number, fetal biometry [biparietal diameter (BPD) - femur length (FL) - abdominal circumference (AC)], placental (site & maturity), liquor (amount described as amniotic fluid index (AFI) & turbidity), and estimated fetal weight calculated to hadlock's formula by sonographic machine software, and assess fetal viability and amount of liquor.

All patients underwent a fetal cardiac examination by 2-dimensional sonography and pulsed wave Doppler sonography. Data were acquired and recorded during the scan. The first fetal echocardiogram was obtained 28 weeks' gestation or more. In cases with a suboptimal echocardiographic window or a suspicion of a lesion, the scan was repeated after 4 weeks. Doppler was used to analyze the fetal cardiac structure and function for all diabetic pregnant ladies for full structural assessment.

Using the M-mode echocardiography during the diastole, the Inter-ventricular septal thickening was measured by placing the M-line perpendicular to Inter-ventricular septum, just below the aortic valves in transverse five-chamber view during the suspended voluntary maternal respiration with no fetal breathing movements. Myocardial hypertrophy was defined as interventricular septum thickness at end-diastole greater than two standard deviations above the normal for gestational age, using previously published nomograms as a reference *(Moghadam et al., 2019)*.

Myocardial Performance Index (MPI) was calculated for both right and left heart by PW Doppler according to Hernandez-Andrade et al. (2012). Three intervals were recorded for each index: Isovolumetric contraction time (ICT), isovolumetric relaxation time (IRT) and ejection time (ET). ICT is the period between mitral/tricuspid valve closure and aortic/pulmonary valve opening. IRT is the period between aortic/pulmonary valve closure and mitral/tricuspid valve opening and ET is the period between aortic/pulmonary valve opening and closure. Mod-MPI = (ICT + IRT)/ET.

Statistical Analysis:

The collected data were coded, processed and analyzed using the SPSS (Statistical Package for the Social Sciences) version 22 for Windows® (IBM SPSS Inc, Chicago, IL, USA). Shapiro – Wilks test was used to test normal distribution of variables. The normality of the parameter's distribution pattern was evaluated by Kolmogorov Smirnov test.

Also, Qualitative variables were assessed by chi-squared (χ^2) or Fisher's exact test. Numerical data were expressed as mean ± standard deviation or median and range. Categorical data were summarized as number and percentages. P value < 0.05 was considered significant.

RESULTS

Distribution of the participants in both studied groups according to their ages showed that majority of the participants in both studied groups (46.3%) were in 18-25 years age group. There were 17 women with controlled diabetes (42.5%) and twenty women with uncontrolled diabetes (50%) had their age ranged between (18-25) years. In addition, 16 patients in both studied groups (40%) had tier age group ranged between 26-30 years, whereas the least number of women were seen in the age group of more than 30 years as 7 cases with controlled diabetes (17.5%) and 4 uncontrolled diabetes cases (10%) were falling in (31-35) years age group.

There was no statistically significant difference in the age distribution of participants between both studied group (P=0.588). The mean age of pregnant women with controlled and uncontrolled diabetes was 26.9±3.44 and 25.62±3.96 years; respectively. There were no statistically significant differences between the two groups regarding to age (P=0.128).

The mean BMI of pregnant women with controlled diabetes was 24.73±2.99 kg/m2 compared to 28.95±4.07 kg/m2 in those with uncontrolled diabetes. The present study indicated that patients with uncontrolled diabetes have significantly higher BMI than those with controlled diabetes (P<0.001).

The mean HbA1c of pregnant women with uncontrolled diabetes was significantly higher than that detected in controlled women with diabetes **(Table 1)**.

Table (1): Distribution of the age and BMI of pregnant women and Mean HbA1c of pregnant women with controlled and uncontrolled diabetes

Groups / Parameters		Group I Controlled diabetes (N=40)	Group II Uncontrolled diabetes (N=40)	P-Value
Age				
18-25	N (%)	17 (42.5%)	20 (50%)	0.588
26-30	N (%)	16 (40%)	16 (40%)	
31-35	N (%)	7 (17.5%)	4 (10%)	
Range Mean ± SD		22–35 26.9±3.44	18–35 25.62±3.96	0.128
BMI (Kg/m^2) Range Mean ± SD		 19–33 24.73±2.99	 20–38 28.95±4.07	<0.001
HbA1c (%) Range Mean ± SD		 4.6–5.8 5.27±0.29	 6.1–8 6.84±0.52	<0.001

The fetal inter-ventricular septal thickness (IVST) was significantly thicker in the uncontrolled diabetes group compared with the controlled diabetes group. It was (4.58±0.87 mm) in the uncontrolled diabetes group compared to (3.69 ± 0.39 mm) in the controlled diabetes group (P<0.001).

In addition, the fetuses isovolumic relaxation time (IVRT) was significantly prolonged in the uncontrolled diabetes group (41.73±3.34 ms) compared with the controlled diabetes group (39.55 ± 2.39 ms) (P=0.001).

The fetal Ejection fraction (EF) was not significantly different in both studied groups (The mean was 0.31±0.05 in the controlled diabetes group compared with 0.33±0.08 in the uncontrolled diabetes group (P>0.05).

We found that the mean myocardial thickness of the right ventricular free wall (RVWT) in the controlled diabetes group was 3.69 ± 0.39 mm and 4.39 ± 0.7 mm in the uncontrolled diabetes group. A significant statistical difference was found regarding the right ventricular free wall myocardial thickness between both diabetic groups (P < 0.001).

The average tricuspid E/A ratio was significantly higher in controlled diabetes group (0.80±0.04) as compared to uncontrolled diabetes group (0.78±0.04), (P=0.01) with nearly same results for mitral E/A ratio. 0.80±0.05 versus 0.78±0.03 in both groups respectively (P=0.01).

Also, lower mitral annular plane systolic excursion (MAPSE), and tricuspid annular plane systolic excursion (TAPSE) were recorded in fetuses belonged to uncontrolled diabetes group (7.39±0.55 & 8.85±0.46) compared to that detected in controlled diabetes group (7.6±0.6 & 9.05±0.61) (P=0.11 & P=0.16).

The LV-MPI and RV-MPI were calculated in all fetuses in the study population. The mean LV- MPI measured 0.47±0.03 in controlled diabetes group vs. 0.46±0.04 in uncontrolled diabetes group (P=0.086) while the mean RV- MPI measured 0.5±0.06 in controlled diabetes group vs. 0.49±0.06 in uncontrolled diabetes group (P=0.261) (Table 2)

Table (2): Cardiovascular function assessed by ultrasound using 2-D and Doppler ultrasound modes

Parameters \ Groups		Group I Controlled diabetes N=40	Group II Uncontrolled diabetes N=40	P-value
IVRT*(ms)*	**Mean ± SD**	**39.55 ± 2.39**	**41.73±3.34**	0.002
	Median (Range)	**39(36–44)**	**42.5(36-48)**	
IVST*(mm)*	**Mean ± SD**	**3.69±0.39**	**4.58±0.87**	<0.001
	Median (Range)	**3.61(3.21–5.25)**	**4.2(3.6-6.7)**	
EF	**Mean ± SD**	**0.31±0.05**	**0.33±0.08**	0.184
	Median (Range)	**0.32 (0.29-0.34)**	**0.32 (0.26-0.35)**	
Right ventricular free-wall thickness (RVFWT) (mm)	**Mean ± SD**	**3.69 ± 0.39**	**4.39 ± 0.7**	<0.001
	Median (Range)	**3.6(3.21–5.25)**	**4.2(3.6–6.3)**	
Tricuspid E/A ratio	**Mean ± SD**	**0.80±0.04**	**0.78±0.04**	0.03
	Median (Range)	**0.82(0.75-0.86)**	**0.77(0.72-0.85)**	
Mitral E/A ratio	**Mean ± SD**	**0.80±0.05**	**0.78±0.03**	0.03
	Median (Range)	**0.80(0.75-0.85)**	**0.77(0.74-0.81)**	
MAPSE (mm)	**Mean ± SD**	**7.6±0.6**	**7.39±0.55**	0.11
	Median (Range)	**7.9(6.55-8.55)**	**7.5(6.55-8.25)**	
TAPSE (mm)	**Mean ± SD**	**9.05±0.61**	**8.85±0.46**	0.10
	Median (Range)	**9.15(8.22-9.65)**	**8.89(7.89-9.55)**	
Left ventricular MPI	**Mean ± SD**	**0.47±0.03**	**0.46±0.04**	0.21
	Median (Range)	**0.47(0.43–0.56)**	**0.45(0.36–0.55)**	
Right MPI	**Mean ± SD**	**0.5±0.06**	**0.49±0.06**	0.458
	Median (Range)	**0.48(0.44-0.65)**	**0.48(0.38-0.65)**	

There was no significant difference between the two studied groups in the number of neonates admitted to NICU and stayed there for more than 15 days (P=0.712). There is no statistically significant different between numbers of babies with neonatal sepsis in both groups (P=1.000). The overall mortality was shown in 2 babies (5%) whose mother had uncontrolled diabetes **(Table 3)**.

Table (3): Frequencies of NICU, neonatal sepsis in pregnant women neonatal death in both studied groups.

Parameters \ Groups		Group I Controlled diabetes N=40	Group II Uncontrolled diabetes N=40	P-value
NICU				
No	**N (%)**	39 (97.5%)	37 (92.5%)	0.615
Yes	**N (%)**	1 (2.5%)	3 (7.5%)	
Neonatal sepsis:				
No	**N (%)**	40 (100%)	39 (97.5%)	1.000
Yes	**N (%)**	0 (0%)	1 (2.5%)	
Neonatal death:				
No	**N (%)**	40 (100%)	38 (95%)	0.494
Yes	**N (%)**	0 (0%)	2 (5%)	

The current study displayed that, among 40 women with uncontrolled diabetes, there were 10 women had 1 min APGAR score < 7 and 5 women had 5 min APGAR score <7 while in those with controlled diabetes there were only 2 women had 1 min APGAR score < 7 and 1 women had 5 min APGAR score <7.

There were statistically significant differences between the two groups regarding number of cases that have 1 min APGAR score (P=0.012) **(Table 4)**.

Table (4): Frequencies of 1 min APGAR and 5 min APGAR score in patients group and control group

Groups / Parameters		Group I Controlled diabetes N=40	Group II Uncontrolled diabetes N=40	P-value
1 min APGAR score:				
No	**N (%)**	38 (95%)	30 (75%)	0.012**
Yes	**N (%)**	2 (5%)	10 (25%)	
5 min APGAR score:				
No	**N (%)**	**39 (97.5%)**	**35 (87.5%)**	**0.201**
Yes	**N (%)**	**1 (2.5%)**	**5 (12.5%)**	

DISCUSSION

According to a previous study *Mohsin et al. (2019),* who found that 18 fetuses of diabetic mothers had myocardial hypertrophy and 32 had normal septal thickness with mitral E/A ratio was lower in gestational diabetes group as compared to the control ($p < 0.001$). Isovolumetric relaxation and contraction times and myocardial performance index were greater in fetuses of gestational diabetic mothers ($p < 0.001$). Based on this assumption, sample size was calculated according to these values produced a minimal samples size of 76 cases were enough to find such a difference. Assuming a drop-out ratio of about 5%.

This study was a prospective study that was conducted on a total of 80 patients who attended outpatient clinics at Obstetrics and Gynecology department, Al-Azhar University Hospital during the period from May 2020 till May 2021. All cases had gestational age above 28 weeks and all suffered from GDM. We measured the glycosylated hemoglobin (HbA1c) levels of the participants; the mean cut off value was 6.5%, where a level of < 6.5% indicates good glycemic control and a level of > 6.5% indicates poor glycemic control. The mean HbA1c of pregnant women with uncontrolled diabetes was significantly higher than that detected in controlled women with diabetes.

Results of the current study revealed that there were no statistically significant differences between the two groups regarding to age. There were 17 women with controlled diabetes (42.5%) and twenty women with uncontrolled diabetes (50%) had their ages ranged between (18-25) years. In addition, 16 patients in both studied groups (40%) had their age group ranged between 26-30 years, whereas the least number of women were seen in the age group of more than 30 years as 7 cases with controlled diabetes (17.5%) and 4 uncontrolled diabetes cases (10%) were falling in (31-35) years age group.

In a recent systematic review and meta-analysis conducted via *Li et al. (2020)* demonstrated a linear increase rather than a threshold effect in the risk of GDM with successive age-groups, with a strong positive association between maternal age and GDM risk. Women aged <20 years had a significantly lower risk for GDM than those aged 20–24 years.

In addition, the present study indicated that patients with uncontrolled diabetes have significantly higher BMI than those with controlled diabetes. No significant difference was detected between the two studied groups regarding parity. *Shah et al. (2011)* found a greater prevalence of GDM among groups with increasing prepregnancy BMIs.

Another study also showed a positive and statistically significant association between obesity and HbA1c >7%, interpreted as poor glycaemic control. The findings from this study revealed that the rates of obesity among diabetes patients were very high, and correspondingly, the percentage of patients with poor glycaemic control was also high, suggesting that lifestyle changes are mandatory for the treatment of both conditions (diabetes and obesity) *(Bae et al., 2016)*.

These results could be explained by the multitude of factors associated with the process of achieving a targeted glycaemic control, such as adherence to treatment, the presence of comorbidities and complications, suggesting that stepped-care approach must be considered in order to obtain successful treatment and of patients with DM *(Mut-Vitcu et al., 2017)*.

As regard echocardiographic assessment, measurement of ventricular myocardial free walls and interventricular septal thickness was done as a tool for evaluation of cardiac hypertrophic cardiomyopathy that occurs in fetuses of diabetic mothers. Doppler-derived modified myocardial performance index (Mod-MPI) was used to assess global overall systolic and diastolic function to display whether impairment of fetal cardiac function occurred or not. Both groups were within a comparable gestational age (between 28- and 38-weeks' gestation).

We found that the fetal inter-ventricular septal thickness (IVST) was significantly thicker in the uncontrolled diabetes group compared with the controlled diabetes group. A significant statistical difference regarding the right ventricular free wall myocardial thickness between both diabetic groups.

Atiq et al. (2017) in a nearly similar study that assessed fetal cardiac function (systolic, diastolic, and global myocardial performance) in the second trimester in mothers with gestational diabetes, and also to relate cardiac function with glycemic control but early in the 2nd trimester (between 19 and 24 weeks reported that IVST was significantly thicker in the poorly- controlled diabetes group compared with the good- controlled diabetes group.

Good glycemic control may delay and perhaps reduce functional cardiac impairment *(Chen et al., 2012)*.

Garg et al. (2014) showed the changes in fetal cardiac structure in women with gestational diabetes compared to those with normal pregnancies. The fetal cardiac wall and septal thicknesses were significantly increased in women with

gestational diabetes, but unlike our results these increases were independent of glycemic control.

Chen et al. (2012) showed that maternal hyperglycemia control could decrease fetal ventricular wall thickness in GDM mothers, but this effect was not statistically significant.

Pilania and his Co-workers (2016) found that IVST was probably not increased in thier study as compared to their level in controls and explicated that because the diabetes was well controlled in their patients.

Uncontrolled diabetes mellitus with altered metabolism, as well as fluctuating glucose levels in early gestation, have a teratogenic effect causing defects in cardiogenesis and cardiac function. This may be related to fetal hyperinsulinemia but is most likely multifactorial. The wide range of cardiac abnormalities found may suggest a complex pathogenesis in these fetuses. This not only has been well described in pregestational diabetes, but is also documented in gestational diabetes, latter being 8–20 times more prevalent *(Atiq et al., 2017)*.

Raafat et al. (2020) a significant difference regarding the septal thickness between diabetic group and normal group ($P < 0.05$).

Miranda et al. (2018) demonstrated also that fetuses of diabetic mothers had a significantly thicker interventricular septum compared with control subjects.

According to *Bogo et al. (2020),* hypertrophic cardiomyopathy in the fetus of a diabetic mother can be considered a functional adaptive process and not a primary cardiac dysfunction. Research has shown that myocardial hypertrophy is of a transitory nature and may disappear in about six months to two years after birth.

In addition, our results showed that the fetuses isovolumic relaxation time (IVRT) was significantly prolonged in the uncontrolled diabetes group compared with the controlled diabetes group. The fetal Ejection fraction (EF) was not significantly different in both studied groups. The average tricuspid E/A ratio was significantly higher in controlled diabetes group as compared to uncontrolled diabetes group with nearly same results for mitral E/A ratio depicting a less compliant left and right ventricles and increased ventricular stiffness. Altered metabolic environment and fluctuations in maternal blood sugar levels may be responsible for the impaired diastolic function.

Also, lower mitral annular plane systolic excursion (MAPSE), and tricuspid annular plane systolic excursion (TAPSE) were recorded in fetuses belonged to uncontrolled diabetes group compared to that detected in controlled diabetes group.

Prefumo et al. (2011) reported that cases of marked fetal myocardial hypertrophy associated with signs of myocardial insufficiency in fetuses of diabetic mothers.

Many authors have reported ventricular diastolic dysfunction in fetuses of diabetic mothers, even in the absence of septal hypertrophy *(Hatém et al., 2012* and *Balli et al., 2014)*.

Balli et al. (2014) showed that the mean septal thickness at 36 weeks gestation was 0.452 ± 0.49 cm in group of

maternal diabetes compared to 0.38 ± 1.77 cm in the control group with a significant statistical difference. In this study, despite being statistically different, no pathological IVS hypertrophy was found. However, evidence of diastolic dysfunction in the study group was found by application of different parameters for assessing diastolic dysfunction.

Mohsin et al. (2019) at around 23 weeks' gestation reported that there was no statistical difference in most of the dimensional variables. However, functional variables showed that mitral E/A ratios were significantly lower in the gestational diabetes group as compared to the control. Isovolumetric relaxation and contraction times were significantly prolonged in fetuses of gestational diabetic mothers and myocardial performance index was also significantly abnormal in the gestational diabetic group as compared to the control.

In both former studies, most of the abnormalities were noted in fetuses whose mother had poor diabetic control.

The increasing E/A wave ratio demonstrated a maturational improvement in ventricular compliance with increasing gestational age leading to a gradual change in filling pressures *(Atiq et al., 2017)*. Isovolumic contraction time (IVCT) reflects systolic contraction times with longer time consistent with poorer contraction *(Van Mieghem et al., 2014)*, while IVRT reflects diastolic or relaxation function, slow relaxation reflecting poor compliance *(Fouda et al., 2013)*.

The myocardial performance index (MPI/ Tei Index) has been reported to be a useful, non-invasive index for global myocardial function as it was firstly introduced by Tei and his co-workers in 1995. It includes both systolic and diastolic time intervals and is independent of both heart rate and ventricular geometry *(Moghadam et al., 2019)*.

In concordance to or results, *Atiq et al. (2017)* showed the poor glycemic control group to have significantly prolonged IVRT. However, no difference was found in most of other cardiac functional parameters between the good and poor glycemic control group of patients, as has been demonstrated by other workers previously. They also reported that significant functional abnormalities in the gestational diabetic group were found compared to the controls in the second trimester. Ventricular filling pressures in the form of E/A ratio showed a less compliant left ventricle than the right ventricle in the gestational diabetic group. Another parameter of left ventricular compliance is the MAPSE which was also significantly less in the study group. TAPSE reflecting right ventricular function was also less but did not reach statistical significance. IVRT, IVCT, and MPI were also significantly deranged in the study group.

Considering neonatal birth weight, it was detected that the neonatal birth weight of women with uncontrolled diabetes was significantly higher than that of those with controlled diabetes. Only 5% of babies delivered in both studied groups were admitted to neonatal intensive care unit (NICU) and stay more than 15 days; 1 of these new born babies for the women with controlled diabetes group while others were in pregnant women with poor diabetes control. Neonatal sepsis has been detected in only 2.5% of mother with

uncontrolled diabetes. The current study displayed that, among 40 women with uncontrolled diabetes, there were 10 women had 1 min APGAR score < 7 and 5 women had 5 min APGAR score <7 while in those with controlled diabetes there were only 2 women had 1 min APGAR score < 7 and 1 women had 5 min APGAR score <7.

González-Quintero et al. (2012) in agreement with our findings reported that women with controlled blood glucose delivered fewer large-for-gestational-age, macrosomic, infants than women with uncontrolled blood glucose. Cesarean delivery (P < 0.001) and neonatal intensive care unit or intermediate care nursery admission were also more common for infants from mothers with uncontrolled blood glucose.

In a study by *Kalyani et al. (2014)* it was noted that incidence of 56% LSCS in GDM group with no still births and intra uterine fetal death (IUFD) in their study like ours.

Pilania et al. (2016) reported that there were only few adverse fetal and neonatal outcomes in their study due to close monitoring, early hospitalization, strict blood sugar control, timely betamethasone therapy and termination of pregnancy at 37-38 weeks of gestation.

Sikarwar and Hatkar (2019) found that majority (70%) of diabetic women underwent cesarean section of which 55% were emergency lower segment CS (LSCS) and 15% were elective LSCS, 25% women had normal delivery 2.5% of these were preterm normal deliveries. they also found that Maximum babies born were in range of 2.5 to 3 kg which is similar to studies conducted.

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تقييم الحالة الوظيفية لقلب الجنين بواسطة الموجات فوق الصوتية في السيدات الحوامل المصابات بمرض السكري

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خلفيـــة البحـــث: أظهـــرت الدراســـات الوبائيـــة أن الأطفـــال الـــذين يولـــدوا لأمهـــات مصـــابات بســـكر الحمـــل لـــديهم مخـــاطر متزايـــدة للإصـــابة بـــأمراض القلـــب والأوعيـــة الدمويـــة فـــي مرحلـــة الطفولـــة ومـــا قبـــل البلـــوغ. وتـــم الابـــلاغ عـــن تغيـــرات مورفولوجيـــة ووظيفيـــة لقلـــب الجنـــين وبخاصـــة فـــي البطـــين الأيمـــن، وهـــو مـــا يتوافـــق مـــع هيمنـــة القلـــب الأيمن في وقت متأخر من الحمل.

الهـــدف مـــن البحـــث: تقيـــيم وظيفـــة القلـــب للجنـــين عـــن طريـــق تخطـــيط صـــدى القلـــب الجنينـــي فـــي مرضـــى ســـكر الحمـــل بمـــا فـــي ذلـــك تقيـــيم الوظيفـــة الانقباضـــية والوظيفـــة الانبساطية وتغيراتها في مرضى سكر الحمل.

المريضـــات وطـــرق البحـــث: كانـــت هـــذه الدراســـة عبـــارة عـــن دراســـة اســـتباقية أجريـــت علـــى 80 مريضـــةً عانـــت جميعـــا مـــن ســـكر الحمـــل وحضـــرن إلـــى العيـــادات الخارجيـــة بقســـم أمـــراض النســـاء والـــولادة بمستشـــفيات الأزهـــر الجـــامعي خـــلال الفتـــرة مـــن مـــايو 2020 حتـــى مـــايو 2021. وقـــد قمنـــا بقيـــاس مســـتويات الهيموجلـــوبين الســـكري (HbA1c) للمشـــاركات؛ وكـــان متوســـط القيمـــة القطعيـــة 6.5٪، حيـــث يشـــير المســـتوى <6.5٪ إلـــى تحكـــم جيـــد فـــي نســـبة الســـكر فـــي الـــدم ومســـتوى> 6.5٪ يشـــير إلـــى ضـــعف التحكم في نسبة السكر في الدم.

نتـــائج البحـــث: كـــان متوســـط الهيموجلـــوبين الســـكري للنســـاء الحوامـــل المصـــابات بســـكر الحمـــل غيـــر المنضـــبط أعلـــى بكثيـــر منـــه فـــي النســـاء المصـــابات بســـكر الحمـــل الخاضـــع للســـيطرة (6.84 ± 0.52٪ مقابـــل 5.27 ± 0.29٪. وأظهـــرت نتـــائج العمـــل الحـــالي أن متوســـط مؤشـــر كتلـــة الجســـم للنســـاء الحوامـــل المصـــابات بســـكر الحمـــل

الخاضع للتحكم كان 24.73 ± 2.99 كجم / م 2 مقارنة بـ 28.95 ± 4.07 كجم / م 2 في المصابات بسكر الحمل غير المنضبط. وأشارت الدراسة الحالية إلى أن مرضى السكري غير المنضبط كان لديهن مؤشر كتلة جسم أعلى بكثير من أولئك الذين يعانون من مرض السكري الخاضع للتحكم. ولم يتم الكشف عن اختلاف معنوي بين المجموعتين المدروستين فيما يتعلق بعدد مرات الولادة السابقة. وفيما يتعلق بتقييم تخطيط صدى القلب، تم قياس جدران عضلة القلب البطينية وسمك الحاجز بين البطينين كأداة لتقييم تضخم عضلة القلب الذي يحدث في أجنة الأمهات المصابات بالسكر. كما تم استخدام مؤشر أداء عضلة القلب المعدل المشتق من دوبلر (Mod-MPI) لتقييم الوظيفة الانقباضية والانبساطية الشاملة لعرض ما إذا كان هناك ضعف في وظيفة قلب الجنين أم لا. وكان عمرالحمل مماثل في كلتا المجموعتين (بين 28 و 38 أسبوعًا) من الحمل.

الاستنتاج: يعد مرض سكر الحمل غير المنضبط عند النساء الحوامل يمكن أن يسبب تغيرات مثل سمك جدار البطين في قلب الجنين، والخلل الانبساطي القلبي خاصةً وقت استرخاء البطين لفترات طويلة، والتي يمكن أن يتسبب في المزيد من العواقب الوخيمة.

الكلمات الدالة: وظيفة القلب للجنين، تخطيط صدى القلب للجنين، السيدات الحوامل المصابات بمرض السكري.