

Fetal cardiac functional performance and development of diabetic gestations

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Received date: January 01, 2017; **Accepted date :** April 20, 2017; **Published date:** April 25, 2017.

Citation this Article: Ahmed Refaat Kotb, Amr Shaaban, Fetal cardiac functional performance and development of diabetic gestations.

Doi: 10.31579/2578-8965/002

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Abstract:

Objective of research

To reveal and assess probable change in fetal cardiac physiological function of pregestational diabetic gestations.

Research design

We performed a prospective research study of 31 gestations between 22 weeks' gestational age and full term, and who had pregestational diabetes. All diabetic women recruited in the research performed had glycosylated hemoglobin lower than 6.5%. All gestations involved in the research performed had an early sonographic confirmation of fetal gestational age. Doppler study of blood flow via the fetal mitral and tricuspid valves were performed every 4 weeks using a pulsed wave sonographic Doppler machine with a 3.5- or 5-MHz ultrasound transducer. The subsequent parameters were analysed and calculated automatically from the revealed flow velocity waveforms: the peak velocity during the rapid ventricular filling phase (E wave) and during the atrial systole phase (A wave), and the ratio between these obtained velocities (E/A ratio); and the velocity time fundamental of the fetal atrioventricular blood flow (correlated with volume flow). A comparative statistical analysis between the Doppler parameters revealed from fetal examination of diabetic gestations and of normal gestations was performed by using the Mann-Whitneytest.

Results

Each gestation recruited for the study performed around four to five fetal echocardiographic Sonographic assessments at 22, 26, 30, 34, and 38 weeks' gestation. The E/A ratio of the mitral and tricuspid valves did not rise in fetuses of diabetic women during the third trimester and was observed to be statistically significantly higher in fetuses of nondiabetic gestations in comparison with fetuses of diabetic gestations at 34 and 38 gestational weeks. Calculated velocity time basic of the mitral and tricuspid valves when multiplied by fetal heart rate was greater, but not statistically significant, in fetuses of nondiabetic gestations when put in comparison with diabetic gestations fetuses at 34 and 38 weeks' gestational weeks. The E-wave of both the mitral and tricuspid valves rised in both study categories all the way through pregnancy. The A-wave of the mitral and tricuspid valves rised only in diabetic gestation fetuses all over the final gestational trimester and was statistically significant in a greater manner at 34 and 38 gestational weeks compared with fetuses of nondiabetic women.

Conclusion

variability in fetal atrioventricular blood flow forms between fetuses of diabetic gestations and normal gestations does not essentially cause variability in fetal functional cardiac compliance.

Key words

Pregestational diabetic gestations, Cardiac Doppler Studies, Echocardiographic Sonographic assessments.



Introduction

Fetal Cardiac hypertrophic changes in of diabetic gestations is a well-known observable fact that could furthermore reason manipulations in future cardiac normal function, influences in fetal intracardiac blood flow in diabetic gestations all the way through course of pregnancy. The chief sonographic tool applied to analyse and examine the fetal intracardiac blood flow features and physiologic cardiac functional performance is Doppler velocimetry indices of atrioventricular blood flow. This significant feature of fetal human cardio vascular system also has been described in a precise manner in physiologically normal fetuses. [1-5].

Congenital heart disease with other abnormalities in fetal cardiac flow functions is observed in 3-5% fetuses of pregestational diabetes pregnancies. Linkage and correlation of congenital heart disease and intracardiac abnormal flow with diabetes almost always exists particularly in poorly controlled cases. [6-15]. Cardiac functional and structural abnormalities could occur as early as before the seventh gestational week probably by abnormal blood glucose levels altering and influencing the genetic expression of a regulatory gene in the developing embryo, responsible for apoptotic cellular changes [16,17]. Another likely molecular and cellular mechanism is the production of free radicals due to metabolic abnormalities causing diabetic embryopathy observed and researched in various animal research studies and is preventable by antioxidants [18,19].

Congenital heart disease is a very frequent anomaly occurs in around 1% of live births. 1 ranging in severity from a small defect between the chambers of the heart to major morphological malformations, and about 33 percent of all congenital heart disease involve major fetal heart defects that necessitate major surgical intervention. Therefore, prenatal detection of abnormalities of heart structures or altered flow functions is crucial in order to improve neonatal survival. Prenatal detection of altered cardiac flow functions enhances better management protocols to be made up to improve outcome. consequently reducing morbidity and death from cardiovascular flow disorders Doppler studies across valvular structures of the heart and four chamber, outflow tract, + 3 vessels and trachea view, raises effectiveness of cardiac screening and improves understanding of fetal cardiac haemodynamics upgrading levels of care in a cost effective manner [8,9].

Aim of the Research

The purposes of the present study were to examine possible changes in cardiac function in fetuses of diabetic mothers by comparing the atrioventricular blood flow patterns of fetuses of diabetic and nondiabetic.

Women and to determine more specifically whether cardiac compliance is reduced in fetuses of diabetic women.

Materials and Methods

The research study was performed between January 2015 and January 2018, our research group performed a prospective research of conceptions with pregestational diabetes between 22 gestational weeks and full term. All recruited diabetic gestations had glycosylated hemoglobin value less than 6.5% and mean blood glucose level less than 105 mg/dL were counseled to participate in the research study. Sonographic early first trimester confirmation of gestational age was performed. If fetal anomalies were revealed or the sonography performed displayed a difference in calculation of gestational age more than 1 week from the age calculated by the LMP, the cases were banned from the research. Informed consent form was obtained from all recruited participants. Thirty-one of 35 diabetic gestational cases attending our Antenatal clinic decided to join this research. Doppler blood flow studies performed for the fetal mitral and tricuspid valves were performed every 4 weeks using an ultrasound machine (Samsung) with a 3.5- or 5-MHz probe.

Using a high pulse-repetition frequency in the cardiac Doppler examination. Two sonographers were involved in each scan. The subsequent parameters and indices were obtained from the velocity waveforms: the peak velocity obtained at the rapid ventricular filling phase of the cardiac cycle (E wave) and during the atrial systole phase of the cardiac cycle (A wave), and the ratio between these obtained velocities (E/A ratio); To enhance and augment the accuracy of these calculated indices and parameters we acknowledged only values obtained with an angle of the beam performed at less than 20 degrees. We research was performed after getting an apical or basal four-chamber sonographic view of the fetal heart. Septal thickness measurement was obtained by using the M-mode of fetal heart.

The statistical progra was used to display and analyze the research data obtained. The mean +/- two standard deviations (SD) was calculated at 22, 26, 30, 34, and 38 weeks' gestation for the different Doppler values. The different Doppler indices obtained in fetuses of diabetic women were compared with the Doppler indices in normal fetuses. The control group was randomly selected in a random manner and involved 25 low-risk gestations who had an early scan for gestational age confirmation. The Mann-Whitney statistical test was applied for comparison of fetuses of diabetic and nondiabetic gestations at various phases of gestation.

Results

	Mitral valve		Tricuspid valve	
	Normal	Diabetic	Normal	Diabetic
E/A ratio				
22 wk	0.65 +/- 0.02	0.62 +/- 0.018	0.65 +/- 0.017	0.63 +/- 0.025
26 wk	0.68 +/- 0.022	0.67 +/- 0.02	0.71 +/- 0.014	0.70 +/- 0.024
30 wk	0.80 +/- 0.024	0.75 +/- 0.022	0.80 +/- 0.024	0.76 +/- 0.03
34 wk	0.88 +/- 0.023	0.75 +/- 0.025	0.90 +/- 0.023	0.7 +/- 0.035*
38 wk	0.95 +/- 0.02	0.77 +/- 0.02*	0.96 +/- 0.018	0.83 +/- 0.032*

Table: 1

Comparison of Cardiac Doppler Studies of Mitral and Tricuspid Valves between Normal Fetuses and Fetuses of Diabetic Women

E/A = E wave/A wave ratio; Data are given as mean +/- standard error of the mean.* $P < .05$ comparing between normal fetuses and fetuses of diabetic women

	normal	Diabetic
Septum thickness(mm)		
22wk	1.9 +/- 0.07	2.3 +/- 0.07
26wk	2.5 +/- 0.07	3.3 +/- 0.08*
30wk	2.8 +/- 0.08	3.9 +/- 0.09*
34wk	3.5 +/- 0.1	4.9 +/- 0.1*
38wk	4.2 +/- 0.1	5.9 +/- 0.12*

Table: 2

Comparison of Cardiac Doppler Studies of Septum Thickness Between Normal Fetuses and Fetuses of Diabetic Women

Data are given as mean +/- standard error of the mean.* $P < .05$ comparing between normal gestation fetuses and fetuses of diabetic gestations.



Every case recruited had five fetal echocardiographic exams at 22, 26, 30, 34, and 38 weeks' gestation. The success rate in obtaining the indices and parameters from the mitral valve was 93% and from the tricuspid valve, 91%. The mean age of mothers in the diabetic research group was 32 +/- 7 years and of nondiabetic research group was 29 +/- 6 years ($P < .05$). The mean gestational age at time of delivery of diabetic research group was 38.1 +/- 1.8 gestational weeks and of nondiabetic women 40.3 +/- 0.9 gestational weeks ($P < .05$). The mean birth weight of infants of diabetic gestations research group was 3780 +/- 756 g and of infants of nondiabetic gestations research group 3405 +/- 541 g ($P < .05$).

Ten diabetic Gestations (38%) and three nondiabetic gestations (10%) had Cesarean mode of delivery ($P < .05$). There was no observed adverse outcomes in either research groups (all Apgar scores greater than 8 and no admissions to the neonatal intensive care unit). Mitral and tricuspid E-wave was raised in fetuses of diabetic gestations the same as in normal gestations fetuses between 22–38 gestational. Mitral and tricuspid A-wave increased only in fetuses of diabetic women between 30 and 38 weeks' gestation and was significantly higher at 34 and 38 weeks' gestation compared with fetuses of nondiabetic women. The interventricular septum was statistically significant as observed and displayed to be thicker in fetuses of diabetic gestations in comparison to normal gestation fetuses between 26 and 38 weeks' of gestation.

Discussion

Two corner stone features of fetal cardiac function can be analysed by examining the blood flow patterns via the atrioventricular valve system. Which involves the, cardiac output or functional performance linked to cardiac output can be calculated at by sonographic study of atrioventricular valve system in absence of cardiac abnormalities.¹ Then, the studying the correlation between the two mechanisms of atrioventricular fetal blood flow, rapid ventricular filling phase (E-wave) and atrial contraction phase (A-wave), reflecting fetal cardiac functions and level of cardiac compliance. In physiologically normal gestations, the E/A ratio of the mitral and tricuspid valves rises all the way through pregnancy.^{4–7} due to an increase of the rapid ventricular filling phase performance (E-wave) throughout pregnancy, since atrial contraction phase (A-wave) is not changed in a significant manner during gestation.⁴ Rise of cardiac stroke volume and subsequent cardiac output all over pregnancy usually occurs due to enlargement of valve orifice size since velocity time indices show moderate changes during gestation. Prior research studies^{8,9} imply that various changes happen in fetal cardiac physiological function in pregestational diabetes gestations; usually and most apparent, the E/A ratio of the mitral and tricuspid valves is observed to be lower in fetuses of pregestational diabetes gestations more than in fetuses of nondiabetic gestations^[2].

Hypothetically, this observed difference could imply poor cardiac compliance in gestational diabetes fetuses. Examining and observing in a meticulous manner the atrioventricular blood flow pattern of diabetic gestations and made the following observations. To begin with, the E/A ratio of the mitral and tricuspid valves did not show a rise in fetuses of diabetic gestations as it did in fetuses of nondiabetic gestation research group all the way through the period of pregnancy studied. It turns out to be statistically significantly lower in manner in fetuses of diabetic gestations when compared to fetuses of nondiabetic gestations that appears only for the duration of the second half of the final trimester of gestation. Additionally, the comparatively small E/A ratio displayed and noticed in fetuses of diabetic gestations is not probably due to poor fetal cardiac compliance. Our research group came to this conclusion due to noticing and displaying the fact that the rapid ventricular filling (E-wave) rises in fetuses of diabetic gestations in the same manner and pattern of rise as in fetuses of nondiabetic gestations all through pregnancy.^[3,4,5,16].

The observed low E/A ratio obtained by our research members resulted from a higher A-wave detected in these fetuses of diabetic gestations in comparison with fetuses of nondiabetic gestations. Although the A wave stays stable all the way through the second half of gestation in observed and sonographically studied normal fetuses, the current research displayed interestingly that, in fetuses of diabetic gestations the A-wave rises during the second half of gestation. Lastly, the elevated A-wave could imply raise fetal cardiac contractility and raised ventricular filling due to change in fetal cardiac output in diabetic gestations [6-15].

Our research cohort involved only fetuses of pregestational diabetes in which the disease was well controlled as determined by HbA1C. However other researchers displayed that as soon as 12 weeks' of gestational age, fetuses of poorly controlled insulin dependent diabetic gestations have a lower E/A ratio as regards the mitral and tricuspid valves in comparison with normal gestation fetuses, additionally it was displayed by the same research group that fetuses of well controlled diabetic state had statistically significant manipulations in fetal cardiac functional performance in comparison to normal gestation fetuses during the early time zone of second trimester gestation. However our research group did not observe these manipulations and functional changes in cardiac performance in fetuses of well-controlled diabetic gestations till the second half of the last trimester of gestation. These variations might result from differences in research study categories, e.g., the value of glycosylated HbA1C implemented was (6.5%) IN comparison with greater indices used by other researchers (8.5%). More research studies on wider scales are required to reveal the significance of Doppler studies in comparison with diabetic control parameters such as Hb A1c.^[19].

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