

Study of Global Left Atrial Shortening in Fetuses of Diabetic Mothers

Paulo Zielinsky, Fabíola Satler, Stelamaris Luchese, Luiz Henrique Nicoloso, Antonio L. Piccoli Jr, Eduardo I. Gus, João Luiz Manica, Marlui Scheid, Silvana Marcantonio, Domingos Hatem
Porto Alegre, RS - Brazil

Objective

To test the hypothesis that left atrial shortening fraction is lower in fetuses of diabetic mothers than in fetuses of mothers with no systemic disease.

Methods

Forty-two fetuses of mothers with previous diabetes or gestational diabetes and 39 healthy fetuses of mothers with no systemic disease (controls) underwent echocardiographic examination. Their gestational ages ranged from 25 weeks to term. The left atrial shortening fraction was obtained with the following formula: (left atrial maximum diameter – left atrial minimum diameter)/left atrial maximum diameter. Data were compared using the Student *t* test, with an alpha level of 0.05.

Results

Mean left atrial shortening fractions in fetuses of diabetic mothers and in those in the control group were 0.39 ± 0.15 and 0.51 ± 0.11 , respectively. This difference was significant with $P < 0.001$.

Conclusion

Left atrial dynamics, with a reduction in global left atrial shortening, is increased in fetuses of diabetic mothers. We speculate that this parameter may be useful in assessing fetal left ventricular diastolic function.

Key words

fetal echocardiography, fetal diastolic function, global left atrial shortening fraction

Alterations in left ventricular relaxation, filling, and compliance are common in fetuses of diabetic mothers. Some studies have suggested that the unidimensional echocardiographic profile of the left atrium may be used as an indicator of abnormalities in left ventricular diastolic function, and that left atrial shortening fraction is proportional to compliance and inversely proportional to left ventricular stiffness constant. The usefulness of atrial shortening as a parameter for assessing fetal diastolic function has not yet been demonstrated.

Gestational diabetes has an incidence of 3.5%, accounting for high morbidity and mortality both for the fetus and mother. Major congenital anomalies affect 4 to 12% of newborn infants of women with clinical diabetes, representing an incidence of malformations approximately 5 times higher than that in the general population. The fetal heart is one of the most affected organs, and 40 to 50% of the congenital defects are located in the cardiovascular system^{1,2}. Becerra et al³ have reported an absolute risk for major cardiac malformations of 8.5 per 100 live-born infants of diabetic mothers.

The increased tendency towards the appearance of disproportional myocardial hypertrophy, especially of the interventricular septum, has already been demonstrated in children of diabetic mothers⁴. The appearance of fetal echocardiography has provided the opportunity to study the disease in the prenatal period, when it is called fetal myocardial hypertrophy^{5,6}. Several case series studied have reported an approximate 30% prevalence of that anatomical change in children of diabetic mothers. Septal hypertrophy has been reported as early as 21 weeks of gestational age, but the prevalence is greater in the third trimester^{7,8}.

Thus, fetal echocardiography should be performed in all pregnancies complicated with diabetes mellitus, because fetal myocardial hypertrophy is frequent, easily detected on examination, and is a potential cause for nonimmune hydrops. Fetal myocardial hypertrophy is characterized by interventricular septum dimensions at the end of diastole greater than 2 standard deviations according to gestational age or greater than 5mm, as this value is greater than 2 standard deviations until the end of pregnancy⁶.

Myocardial hypertrophy involving the right ventricle and left ventricular posterior wall may occur, but septal hypertrophy is usually more marked. The presence of a gradient in the left ventricular outflow tract reveals the obstructive forms of the disease. The changes in myocardial compliance and relaxation cause an altered pattern of diastolic filling, with an elevation in intraventricular pressure, which is retrogradely transmitted to the left atrium and pulmonary circulation⁹.

Previous studies ^{10,11} have shown that the linear motion of the septum primum is increased during fetal breathing ¹⁰ and decreased in fetuses with septal hypertrophy of diabetic mothers ¹¹. These findings suggest that the left atrial pressure depends on left ventricular diastolic function.

Some authors have shown that the unidimensional left atrial profile (M mode) may be used as an indicator of abnormalities in left ventricular diastolic function ^{12,13}. Briguori et al ¹⁴, studying diastolic function in adults with hypertrophic cardiomyopathy, suggested that the left atrial shortening fraction was proportional to compliance and inversely proportional to the left ventricular stiffness constant.

No study assessing the fetal diastolic function through the unidimensional left atrial profile was found. Studies assessing diastolic function in fetuses of diabetic mothers are scarce. We speculate that the assessment of left atrial shortening may represent an alternative for evaluating diastolic function in fetuses of diabetic mothers. Therefore, this study aimed at testing the hypothesis that left atrial shortening may be lower in fetuses of diabetic mothers than in healthy fetuses of nondiabetic mothers.

Methods

This study examined pregnant women with gestational ages ranging from 25 weeks to term, who were referred to the Fetal Cardiology Unit of our institution from different obstetrical services in Porto Alegre.

Forty-two fetuses with gestational ages ranging from 25 weeks to term, whose mothers had previous or gestational diabetes, were examined in a sequential, random manner. The control group comprised 39 healthy fetuses with gestational ages ranging from 25 weeks to term, whose mothers did not have diabetes. Those fetuses were also examined in a sequential, random manner.

The following fetuses were excluded from the study: those with gestational ages below 25 weeks; those with any other congenital malformation; those whose mothers had any systemic disease other than diabetes mellitus.

The diagnosis of gestational or previous diabetes was performed according to the criteria recommended by O'Sullivan and Mahan ¹⁵.

The equipment used was an ASPEN model Acuson echocardiography device with a 4 to 7-MHz curve transducer or a 2.25 to 4-MHz phased array transducer with the ability to produce 2-dimensional, M-mode, Doppler, and color mapping images.

The fetuses were included in the study when the images obtained were considered of appropriate quality and when a cardiac anomaly other than septal hypertrophy was ruled out. The fetal echocardiographic examinations were comprehensive and followed the segmentary sequential approach ^{8,9}, beginning in the maternal umbilical region, and searched the following fetal anatomical references: vertebral column, liver, and the septum primum. Then, the following parameters were determined: atrial situs; position of the heart in the thorax; and type and mode of the atrioventricular and ventriculoarterial connections, aortic arch, and occasionally associated defects. Unidimensional left atrial echocardiography was performed in the longitudinal view, oriented by 2-dimensional image, and simultaneous recording of the aortic valve and left atrium was obtained (fig. 1). The left atrial shortening fraction was calculated with the following formula:

$$\frac{\text{telesystolic maximum diameter} - \text{presystolic minimum diameter}}{\text{telesystolic maximum diameter}}$$

telesystolic maximum diameter

All fetal echocardiograms were recorded on magnetic tapes. Data were compared using 2-tailed Student *t* test for independent samples. The statistical significance level adopted was 0.05.

Results

Mean gestational age of fetuses from mothers with previous or gestational diabetes (cases) was 31.4 weeks, and that of fetuses of mothers with no systemic disease (controls) was 30.3 ± 2.35 weeks. No significant difference in the gestational ages was observed between groups ($P = 0.06$).

Figure 2 shows left atrial shortening fractions of the 42 fetuses of diabetic mothers, whose mean was 0.39 ± 0.15 (0.12-0.67), and left atrial shortening fractions of the fetuses in the control group, whose mean was 0.51 ± 0.11 (0.07-0.68).

A statistically significant difference was found between groups, with $P < 0.001$.

Discussion

The knowledge of the fetal cardiocirculatory dynamics has been expanded over the past years with the constant aggregation of new concepts. Doppler echocardiography is an adequate noninvasive method for studying fetal diastolic function ¹⁷⁻¹⁹. During intrauterine life, the systemic and pulmonary circulations work in parallel. Classically and until recently, the assessment of diastolic function only

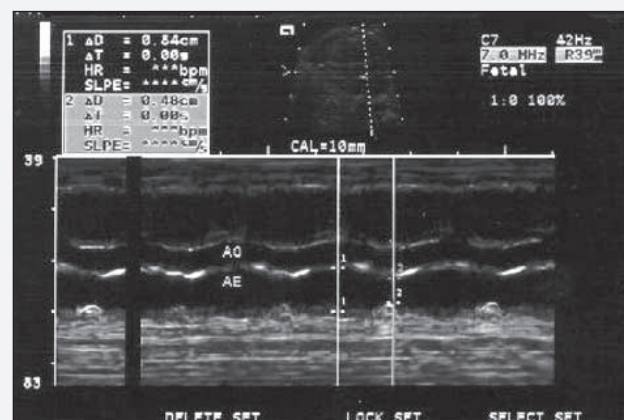


Fig. 1 - Unidimensional image of the left atrium showing the obtention of the atrial telesystolic (1) and presystolic (2) diameters.

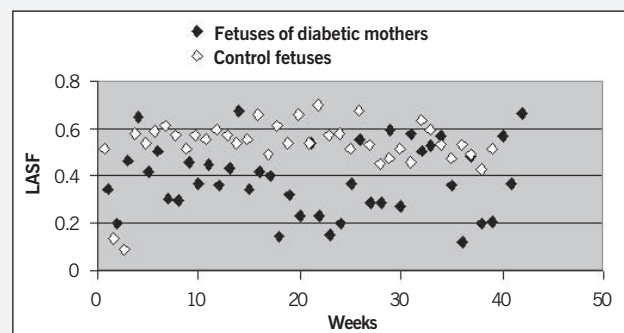


Fig. 2 - Left atrial shortening fractions (LASF).



used the study of mitral and tricuspid flows²⁰. The profile of ventricular filling through the atrioventricular valves shows a more elevated diastolic velocity in the phase of atrial contraction (A wave) than that in the phase of rapid filling at the beginning of diastole (E wave)²¹. As the gestational age increases, the E/A ratio also tends to increase, because the passive rapid filling (E wave) tends to predominate over the atrial contraction (A wave), which is later confirmed in extrauterine life^{22,23}. Studies comparing the evolutionary pattern of the E/A ratio throughout pregnancies of diabetic women and controls have reported that that ratio always remains lower in fetuses of diabetic mothers at the level of tricuspid and mitral valves. Thus, the active ventricular filling fraction (atrial contraction) remains abnormally elevated as compared with the passive ventricular filling during the entire pregnancy, which may occur due to a change in ventricular compliance^{22,24}. Although the factors determining the velocity profile through the atrioventricular valves, which determine diastolic ventricular filling²⁰, are basically the same, it is worth nothing that Doppler measures velocity, and that, based on that measure, the pressure gradient is calculated. Ventricular performance during diastole is fundamentally the result of the relations between pressure and volume²⁵, measurements that the method does not directly provide²⁶.

Due to this, new parameters have been evaluated for completing fetal diastolic function assessment. The previous demonstration that the motion of the septum primum is decreased in the presence of myocardial hypertrophy in fetuses of diabetic mothers¹¹ confirmed the idea that left atrial pressure relates to left ventricular diastolic volumes. Therefore, we found it logical to speculate that left atrial dynamics, especially its parietal motion, could be decreased in the presence of an alteration in left ventricular compliance or relaxation, or both. The study by Briguori et al¹⁴ in adults suggested that left ventricular diastolic function could be better assessed through left atrial motion than through atrioventricular flows in patients with hypertrophic cardiomyopathy. Thus, our study was designed to assess the behavior of left atrial shortening in fetuses of women with diabetes mellitus, whose diastolic function is altered as compared with that in healthy fetuses.

This study showed the existence of an alteration in global left atrial shortening in fetuses of women with previous or gestational diabetes. This finding suggests that this parameter may be used for assessing fetal left ventricular diastolic function. This information could represent an advance in understanding fetal cardiocirculatory physiology and affect the perinatal management of fetuses of diabetic women.

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