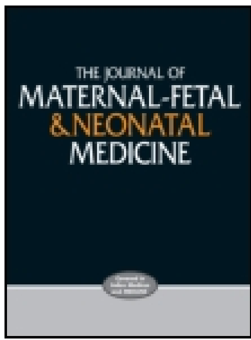

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ORIGINAL ARTICLE

Modified myocardial performance index is not affected in fetuses with an isolated echogenic focus in the left ventricle

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Abstract

Objectives: We prospectively investigated the efficacy of modified myocardial performance index (mod-MPI) in the assessment of cardiac functions in fetuses with and without an isolated hyperechogenic focus (IHF) in the left ventricle and compared with conventional fetal echocardiography.
Methods: The study group consisted of 50 fetuses with only an IHF in the left ventricle, without any other cardiac or extracardiac anomalies; 50 fetuses without IHF served as controls. All fetal echocardiographic studies were performed between 20th and 24th weeks of gestation. Left ventricular functions were evaluated with both conventional echocardiographic methods (peak velocity of the aortic valve, mitral E/A ratio, fractional shortening) and mod-MPI.
Results: There was no statistically significant difference between the groups in terms of maternal age, BMI or gestational age at the time of examination ($p > 0.05$ for all). No statistically significant differences were found between the findings of conventional echocardiographic measurements and left ventricular mod-MPI between the study and control groups ($p > 0.05$ for all).
Conclusion: Fetal left ventricular mod-MPI is not affected by the presence of an IHF in the fetal left ventricle between 20th and 24th gestational weeks and thus it does not need to be assessed in this situation.

Keywords

Fetal echocardiography, isolated hyperechogenic focus, modified myocardial performance index

History

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Introduction

Isolated hyperechogenic focus (IHF), a frequent finding in third trimester fetal echocardiography, is usually observed as a small bright focus in the left and/or right ventricle, with an echogenicity similar to bone density. It has been reported in 3–5% of healthy fetuses and has been linked to microcalcifications in the papillary muscle [1]. Although usually considered benign, it has seldom been associated with cardiac dysfunction [2].

The Tei index (myocardial performance index – MPI) is preferred for assessment of cardiac functions in fetuses, as it can detect ventricular dysfunction through global assessment of ventricular systolic and diastolic functions [3]. In this index, ventricular systolic functions are evaluated with isovolumetric contraction time (ICT) and ejection time (ET), and diastolic functions with isovolumetric relaxation time (IRT). MPI is calculated with the formula ICT + IRT/ET and is prolonged in cardiac dysfunction [4,5].

The original MPI index defined by Tei et al. [6] was formulated as $MPI = (a - b)/b$, where a is the mitral inflow current time obtained by PW Doppler (the time from the onset of the mitral E wave to the end of the mitral A wave, thus ICT + ET + IRT) and b is the aortic outflow current time (ventricular ejection time, ET). The time intervals had to be measured from separate cardiac cycles, which limited its usability in fetal echocardiography. To overcome these difficulties, Friedman et al. [7] suggested a technique to measure all time intervals in one waveform. They placed the PW Doppler cursor beneath the mitral valve, passing through the medial wall of the aorta in the apical five-chamber position. However, it was difficult to determine the starting and ending points of the time intervals with this technique. This issue was in turn resolved by Hernandez et al. in 2005 by extending the Doppler cursor through the anterior aortic wall and placing the Doppler sample volume at the beginning of the anterior mitral valve just below the aortic valve, using the same five-chamber view as defined by Friedman et al., hence the proposed definition ''modified Tei index'' (mod-MPI). In this measurement, the opening and closing motions of the mitral and aortic valves provided clear sharp echo images

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in the Doppler tracing, which were named ''clicks'' and taken as the starting and ending points in measurements [8].

In recent years, many authors have recognized mod-MPI as the earliest and most reliable parameter showing myocardial dysfunction in the fetus [8–11]. However, in the literature, there is no study evaluating cardiac functions of the fetuses with IHF by mod-MPI. Our aim in this study was to investigate the effects of the presence of IHF in the left ventricle on fetal cardiac functions using the mod-MPI.

Materials and methods

For the purpos of this study, the required sample size (with 80% power and a type α error of 0.05) was calculated as 40 for each group to determine whether a significant difference exists between the two groups, with a predicted mean mod-MPI value and standard deviation of 0.39 ± 0.04 for the study group and 0.36 ± 0.04 for the control group, based on the results of previous studies. After power analysis, data from 355 healthy pregnant women, with normal obstetric ultrasonography and antenatal follow-up, who were referred within the last six months for fetal echocardiography between the 20th and 24th gestational weeks were prospectively collected. The study was approved by the institutional ethics committee and all subjects gave written informed consent. The study group consisted of 50 fetuses with an IHF detected in the left ventricle and no other abnormality in fetal echocardiography. Data obtained from 50 fetuses with normal fetal echocardiographic examination and no IHF formed the control group. IHF dimensions were measured using two-dimensional echo images in the apical four-chamber view. Data for calculation of mod-MPI was collected using PW Doppler [8]. All fetal echocardiographic measurements were made by a single experienced pediatric cardiologist (YY) with a calculated intra-class correlation coefficient of 0.824, revealing a high reproducibility ($p = 0.018$).

During the study, mothers were required to hold breathing momentarily to reduce fetal movements. The fetal heart was visualized initially in the apical four-chamber and then the apical five-chamber view to display the aortic output better. In this position, the PW Doppler sample volume was placed on the anterior mitral valve leaflet just below the aortic valve and clicks recorded, as explained above (Figure 1). The following time intervals were measured: from the mitral valve closing line to the aortic valve opening click (ICT), between the aortic valve opening and closing clicks (ET), from the aortic valve closing click to the mitral valve opening click (IRT). The time intervals were measured from the clicks' peaks, with the insonation angle kept below 15 degrees and Doppler aliasing avoided, as proposed by Meriki et al. [12]. Results of four measurements were averaged. The mod-MPI was calculated with the formula: ICT + IRT/ET [4,6]. Left ventricular systolic and diastolic functions were assessed with M-mode and PW Doppler, respectively [13]. All echocardiographic studies were performed using the M-mode, B-mode and PW Doppler methods with a 3S transducer on a Vivid-6S 256 model device (GE-Vingmed Ultrasound AS, Horten, Norway).

Statistical analysis

Windows SPSS 18 software (PASW Statistics for Windows, Version 18.0, Chicago, IL) was used for statistical analysis. The distributions of the groups were evaluated with the Kolmogorov–Smirnov test in addition to graphical methods. The difference between mean of the parameters that meet the normal distribution was evaluated with Student's *t*-test and the results were given as mean ± standard deviation. The difference between the median of the parameters which do not meet the normal distribution was evaluated with the Mann–Whitney *U*-test. The results were given as median (inter-quartile range). A p value of less than 0.05 was considered statistically significant.

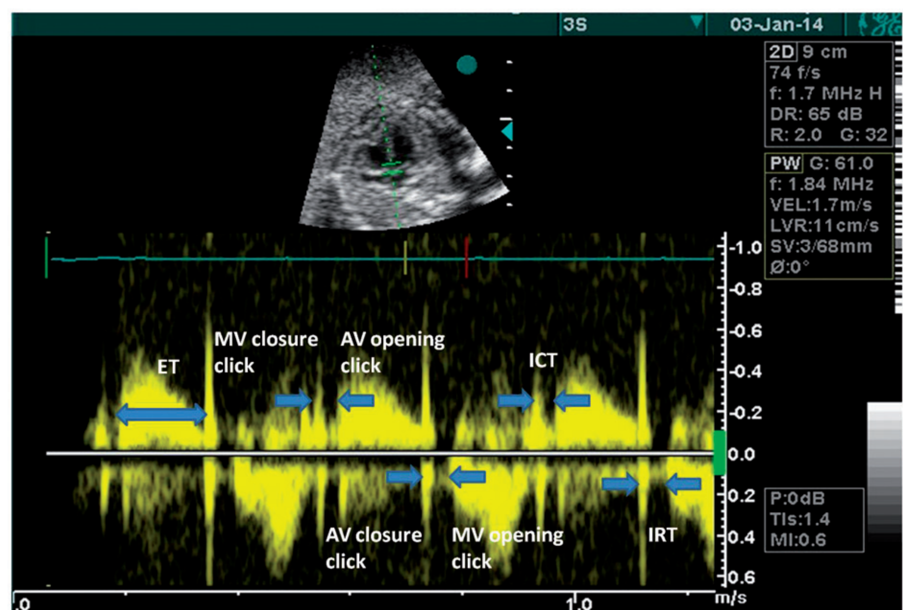

Figure 1. The figure shows aortic valve (AV) and mitral valve (MV) opening and closing clicks, isovolumetric contraction time (ICT), ejection time (ET) and isovolumetric relaxation time (IRT). The mod-MPI: (ICT + IRT)/ET.

Results

There was no statistically significant difference between the groups in terms of maternal age ($p = 0.234$), gestational week ($p = 0.217$) or BMI ($p = 0.645$) (Table 1). The diameter of left ventricular IHF was 3.50 ± 0.82 mm (range 2.4–5.4; median 3.4). There was no difference between the study and control groups in terms of left ventricular systolic and diastolic functions ($p > 0.05$ for all; Table 1). Scatter charts of distributions of the mod-MPI values according to the gestational week are shown in Figures 2 and 3. Also, there were no statistically significant differences between the groups in terms of the parameters used in the calculation of left ventricular mod-MPI ($p = 0.440$ for ICT, $p = 0.218$ for IRT and $p = 0.225$ for ET; Table 1).

Discussion

Schechter et al. [14] were the first to report presence of a hyperechogenic focus in the fetal heart in 1987. Although initially associated with Down syndrome, no relationship could be proven between presence of IHF and chromosomal abnormalities or other risk factors for miscarriage [15–18]. Conventional echocardiography and tissue Doppler imaging studies failed to show any adverse effect on fetal cardiac functions [15,19,20]. However, in 2001, Degani et al. [2] reported diastolic dysfunction in association with IHF. In this study, 48 fetuses with left ventricular IHF and 50 healthy controls were compared for indices of cardiac function. There was no difference between groups in terms of systolic function; however, fetuses with IHF showed signs of diastolic dysfunction (lower E/A ratio) in both ventricles. In our study, there was no significant difference between the study and control groups in terms of mitral E/A ratio or left ventricular fractional shortening values.

Table 1. Comparison of demographic and echocardiographic data obtained from the study and control groups.

	Study	Control	*p*
Maternal age (year)	28.72 ± 4.9	27.88 ± 5.2	0.234
Gestational age (week)	22.44 ± 1.47	22.08 ± 1.38	0.217
BMI	26.34 ± 1.07	25.74 ± 1.18	0.645
IHF diameter (mm)	3.50 ± 0.82	n/a	n/a
Mitral E	34.74 ± 3.41	33.55 ± 2.8	0.416
Mitral A	61.94 ± 5.41	60.52 ± 3.62	0.071
E/A	0.54 ± 0.35	0.53 ± 0.32	0.996
ICT	30.10 ± 5.00	29.38 ± 4.25	0.440
IRT	34.26 ± 4.52	33.88 ± 3.84	0.218
ET	178.88 ± 10.56	176.60 ± 7.88	0.225
mod-MPI	0.36 ± 0.04	0.35 ± 0.03	0.486

FS: fractional shortening, ICT: isovolumetric contraction time, ET: ejection time, IRT: isovolumetric relaxation time, mod-MPI: modified myocardial performance index.

MPI is a reliable index used in both adult and pediatric patients for early detection of cardiac dysfunction as it measures global systolic and diastolic functions independently of ventricular geometry [21–23]. In recent years, the mod-MPI is being increasingly utilized for early detection of fetal cardiac dysfunction.

The mean left ventricular MPI in healthy fetuses has been reported by Eidem et al., Friedman et al. and Hernandez et al. as 0.41, 0.53 and 0.36, respectively [24]. The mean mod-MPI was 0.35 ± 0.03 in our control group, consistent with the normative values reported by Hernandez for healthy fetuses [24].

The mod-MPI is significantly prolonged in fetuses of pregnant women with complications, such as preeclampsia, intrauterine growth restriction, oligohydramnios, twin-to-twin transfusion syndrome (TTTS) or diabetes mellitus [4,5,25,26]. The mechanism was presumed to be hypervolemia and increased afterload, which are predominantly reflected in prolongation of the ICT. In our study, there was no significant difference between the study and control groups when mean mod-MPI and ICT were compared. Presence of an IHF may

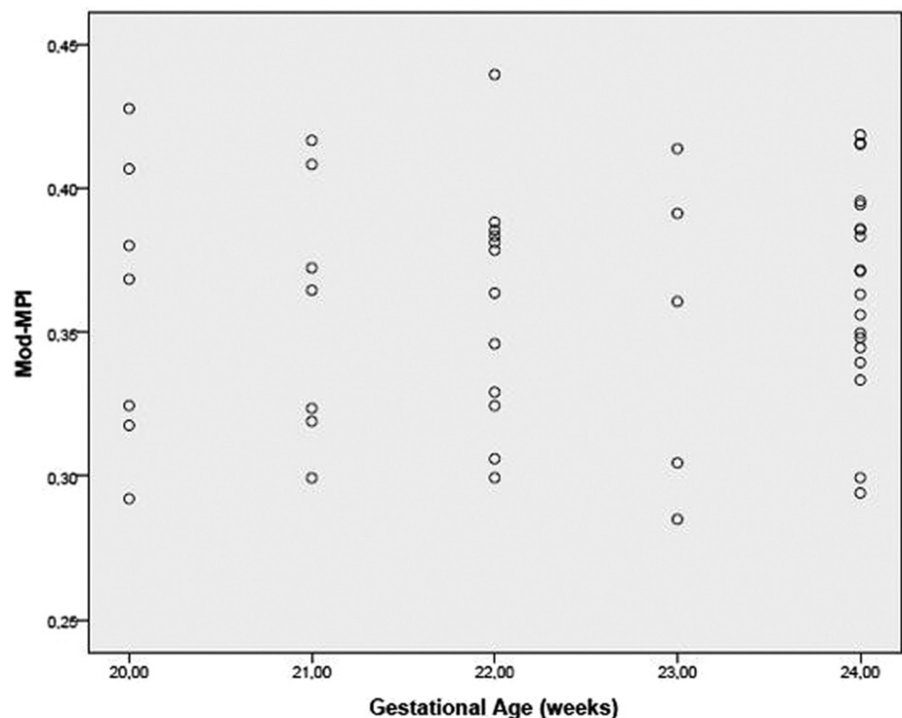

Figure 2. Dot plot of the study group mod-MPI data according to the gestational week.

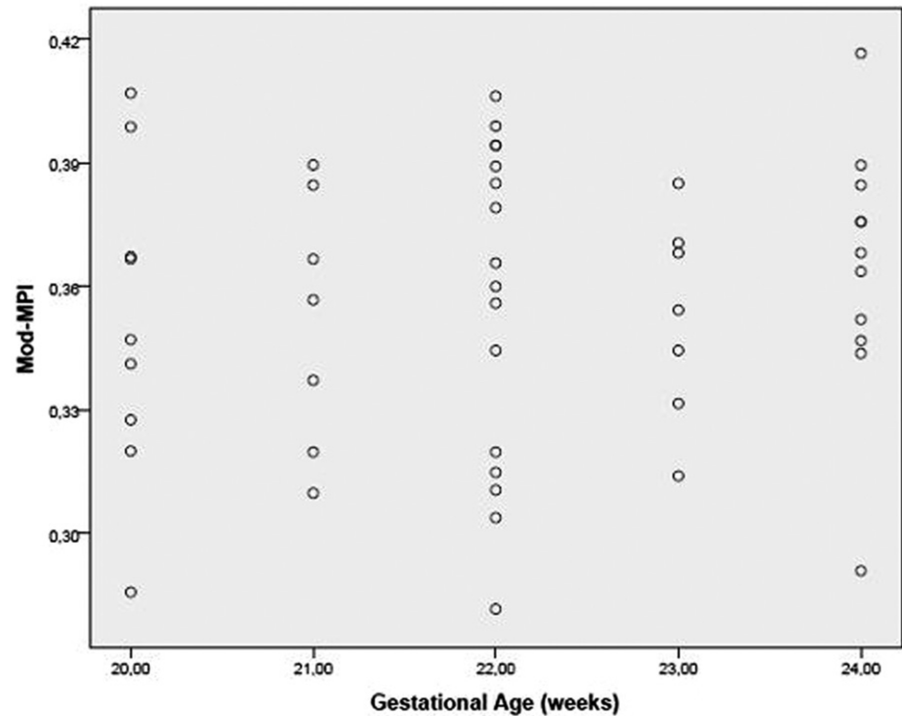

Figure 3. Dot plot of the control group mod-MPI data according to the gestational week.

not cause hypervolemia and increase in afterload, but may cause difficulty in the opening of the mitral valve and prolong passive left atrial flow to the left ventricle. This situation may be reflected as diastolic dysfunction and prolongation of mod-MPI in fetal echocardiography. However, we were not able to show any significant differences between the groups with either conventional echocardiography or mod-MPI measurements in our study.

Kurtulmuş et al. [20] have reported that presence of IHF did not disrupt fetal myocardial functions. Though theirs is the only study in the literature to evaluate the cardiac functions in fetuses with IHF by means of MPI, these researchers have produced MPI data from tissue Doppler imaging in a non-homogeneous group of pregnant women between 19th and 29th weeks of gestation and have included fetuses with both right and/or left ventricular IHF. In our study, however, a homogenous study group (only left ventricular IHF in fetuses of pregnant women between 20th and 24th gestational weeks) and a technique capable of estimating active hemodynamic status, the mod-MPI, were utilized. Although the methods differ significantly, we have also found that presence of IHF in the left ventricle did not affect left ventricular functions.

To conclude, we have found that presence of an IHF in the fetal left ventricle does not affect the left ventricular functions and its presence does not necessitate scrutinization of left ventricular functions.

Study limitations

Although the right ventricle is the dominant ventricle in fetal life, we evaluated only the left ventricular functions in fetuses with a left ventricular IHF; however, we do not consider this to be a limitation of our study. Calculation of left ventricular mod-MPI requires placement of the PW Doppler sample volume on a single location and allows for recording all necessary intervals on a single beat. However, calculation of right ventricular mod-MPI requires placement of the sample volume on the pulmonary valve and tricuspid valve, which cannot be accomplished on a single beat. Studies on the relationship between right ventricular IHF and right ventricular functions can be possible with advanced methods.

Declaration of interest

The authors report no conflicts of interest. The authors alone are responsible for the content and writing of this article.

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