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Accuracy of Fetal Cardiac Function Measured by Myocardial Performance Index in Fetal Intrauterine Growth Restriction

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ABSTRACT

Background & Objective: IUGR (intrauterine growth restriction) fetuses have been known as a significant concern in clinical practice. It is associated with fetal mortality and morbidity and prenatal adverse cardiac remodeling. The aim of this study is the evaluation of the relation between MPI (myocardial performance index) abnormalities and doppler findings in both normal and IUGR fetuses.

Materials & Methods: In this cross-sectional study, 400 consecutive pregnant women in Shariati Hospital, Tehran, Iran, in 2019 and 2020 underwent ultrasound assessment at 28-40 weeks, in which among the 400 performed ultrasounds, 47 fetuses with IUGR were selected as a case group, and 47 fetuses with normal weight were selected based on AGA (appropriate gestational age). Cardiac function was evaluated by measuring MPI in diastolic and systolic function in two groups. The results were compared to the IUGR (case group) and control group by SPSS software version 20.

Results: In receiver operating characteristic (ROC) analysis, the AUC (area under the curve) for left ventricular MPI (LV MPI) was 0.929 (CI95%: 0.868-0.991; *P*=0.001), and the sensitivity and specificity values were 87% and 69.4% with a cut-off point of 0.2850. In ROC analysis, the area under the curve for RV MPI was 0.842 (CI95%: 0.741-0.942; *P*=0.001), and the sensitivity and specificity values were 78.3% and 63.9%, with a cut-off point 0.2850. Left and right ventricular MPI showed a significant difference statistically between the case and the control groups.

Conclusion: The study showed a significant rise of MPI in IUGR fetuses. MPI can be considered as a useful parameter for evaluating the severity of growth restriction in IUGR fetuses.

Keywords: Cardiac function, Fetus, MPI, Pregnant women, Ultrasound

Introduction

Traditionally, intrauterine growth restriction (IUGR) is defined as <10th percentile weight for gestational age. An abdominal circumference below the 10th percentile for gestational age can also be used to describe IUGR. Approximately 5-10% of pregnancies involve IUGR, which is an essential source of perinatal morbidity and mortality **(1-3)**. IUGR results from intrinsic fetal factors such as aneuploidy, congenital malformations, and uteroplacental insufficiency **(4-5)**. Uteroplacental insufficiency usually is an effective prognosis for the risk estimation of adverse prenatal outcomes **(6-7)**. The fetal weight below the 3rd percentile and abnormal Doppler findings are consistent and reliable predictors of adverse pregnancy outcomes **(8-9)**. Umbilical artery Doppler index rises because of high resistance in the placental vasculature **(10)**. Also, reducing the middle cerebral artery Doppler index leads to preferential perfusion of the brain **(11)**. Chronic hypoxia in IUGR fetuses could cause cardiac performance deterioration **(12)**. Fetal cardiac performance deteriorates with a progressive increase in resistance of the umbilical artery **(13)**.

Various modalities are conventionally used to diagnose and screen the deterioration of the IUGR fetuses. Although assessment of cardiac function by echocardiography has conventionally been limited to a

volume-based approach, recent progress in cardiac ultrasound allows the noninvasive measurement of cardiac function by direct evaluation of myocardial muscle by regional myocardial strain. Myocardial performance index (MPI) has demonstrated high sensitivity for the diagnosis of preclinical myocardial dysfunction in various pathological conditions with preserved ejection fraction **(14)**. The myocardial performance index has been known as a Doppler echocardiography method that can be used to assess systolic and diastolic cardiac ventricular function that is commonly known as an early marker of fetal cardiac dysfunction. MPI can demonstrate cardiac adaptation to primary stages of impaired doppler and ventricular dysfunction **(15-16)**.

The literature suggests that abnormal MPI was initially presented in the early stage of fetal deterioration before identifying the Doppler study's abnormal findings in certain vessels **(17-18)** and a decrease in amniotic fluid in the IUGR fetus **(19-20)**. IUGR is associated with a global adverse cardiac remodeling in the uterus and increased cardiovascular morbidity in adults **(21-22)**.

In this study, the MPI in IUGR fetuses was investigated. The relationship of MPI with Doppler deterioration was evaluated for predicting and assessing the severity of growth restriction in IUGR fetuses.

Materials and Methods

In this cross-sectional study, 400 pregnant women attending Shariati Hospital, Tehran, Iran, between 2019 and 2020 underwent ultrasound assessment (28-40 weeks). Gestational age was calculated based on the last menstrual period and verified by the first-trimester ultrasound. All patients were examined by transabdominal ultrasound (with a curvilinear 2–7-MHz probe) (Philips Health Care AFINITY70w). Initially, standard fetal biometry was performed, and then EFW (estimated fetal weight) was measured based on Hadlock's formula. The amniotic fluid volume was assessed by the amniotic fluid index; among the 400 ultrasounds performed, 47 IUGR fetuses were identified as the case group, and 47 fetuses with normal weight were selected as the control group based on appropriate gestational age (AGA). In both groups, MPI was evaluated and compared between the two groups.

In order to evaluate MPI, a cross-sectional image of the fetal thorax with an apical projection of the fetal heart was taken at the level of the four-chamber view. For measurement of left MPI, the Doppler sample volume was located in the left ventricle to include the lateral wall of the ascending aorta and the mitral valve.

Moreover, the minute spikes of blood flow related to valve click corresponded with the aortic valve's opening and closing. They had to be observed to confirm the correct measurement. The IVRT (isovolumetric relaxation time), IVCT (isovolumetric contraction time), and ET (ejection time) were measured utilizing the clicks of the aortic valve as landmarks. Right MPI was calculated by placing the Doppler sample volume on the tricuspid valve. The Doppler gate was opened adequately to simultaneously measure the waveform of the right ventricular outflow and inflow. The valve clicks of pulmonic valves were used as the landmark for the measurement. Three successive measurements of all the parameters were obtained, and MPI was calculated from the average of each interval using the formula: MPI = IVCT + IVRT/ET **(23)**.

Inclusion criteria were pregnant women with IUGR & AGA fetus, normal amniotic fluid, no background disease, normal anatomic survey, and singleton pregnancy. Exclusion criteria included twin or multiple pregnancies, oligohydramnios, abnormal fetus, and preexisting diseases in parents. Based on previous studies, to detect at least a difference of 0.13 in the mean of MPI between the IUGR and the control group with a standard deviation of 0.21, a sample size of 47 subjects were needed in each group, assuming a power of 0.8 and a significance level of 0.05. The local ethical committee approved the study. The ethical approval code is IR.TUMS.MEDICINE.REC.1399.151.

Data analysis was done in 47 cases (IUGR fetuses) and 47 controls (AGA fetuses). Kolmogorov-Smirnov, Chi-Square, Fisher, and Independent-Sample-T tests were utilized (to compare the findings in two groups). The P-values under 0.05 were considered statistically significant by SPSS software version 20 (SPSS Inc., Chicago, IL., USA).

Results

Demographic and background data are shown in Table 1, and all were matched between the two groups.

Table 1. Background data in groups

	Case group (n=47)	Control group (n=47)	P-value
Age (years)	32.26 ± 3.12	31.56 ± 5.47	0.121
IUGR age (weeks)	34 ± 3	35 ± 3	0.430
Body mass index (kg/m²)	26.74 ± 4.35	25.4 ± 4.97	0.296

Doppler and MPI findings are presented in Table 2. The mean AC (abdominal circumference), EFW **(e**stimated fetal weigh**)**, UA PI (umbilical artery pulsatility index), UTA PI (uterine artery pulsatility index), LV MPI (left ventricular myocardial performance index), and RV MPI (right ventricular myocardial performance index) of the two groups are shown in Table 3. AC, EFW, UA PI, UTA PI, LV MPI, and RV MPI was significantly different between the case and the control groups (P<0.001). The mean AC and EFW were significantly different between the case and control groups (4.3±1.8 versus 38.3 ± 17.6) (P<0.001) and (1625.6±502.4 versus 2313.4±552.1) (P<0.001). The AFI (amniotic fluid index) was significantly different between the two groups (10.7±2.5 and 13.8±2.8) (P<0.001). Abnormal UA PI was statistically different between the two groups (20 (43.5%) versus 4 (8.3%) (P=0.001)). The mean UTA PI was abnormal in 26 (56.5%) and 7 (16.7%) in the case and control groups, respectively, which was significantly different between the two groups (P=0.001). Abnormal LV MPI was seen in 36 (78.3%) and 5 (11.1%) in case and control groups, respectively, which was significantly different between the two groups (P<0.001). Abnormal RV MPI was seen in 32 (69.6%) and 10 (22.2%) in case and control groups, respectively, which was significantly different between the two groups (P<0.001). Global fetal heart hypertrophy was statistically seen more in the cases (21.7% versus 0% (P=0.007)).

As demonstrated in Figure 1, in ROC analysis, the area under the curve for LV MPI was 0.929 (CI95%: 0.868-0.991; P=0.001), and the sensitivity and specificity values were 87% and 69.4% with a cut-off point of 0.2850.

According to Figure 2, in ROC analysis, the area under the RV MPI curve was 0.842 (CI95%: 0.741-0.942; P=0.001), and the sensitivity and specificity values were 78.3% and 63.9% with a cut-off point of 0.2850. When abnormal Doppler findings were seen in IUGR fetuses, the MPI was higher, concordant with increased IUGR stage.

Table 2. Abnormal results of UA PI, UTA PI, LV MPI, and RV MPI in the groups

	Case group (n=47)	Control group (n=47)	P-value
UA PI (umbilical artery pulsatility index)	20(43.5%)	4(8.3%)	0.001
UTA PI (mean) (uterine artery pulsatility index)	26(56.5%)	7(16.7%)	0.001
LV MPI (left ventricular myocardial performance index)	36(78.3%)	5(11.1%)	< 0.001
RV MPI (right ventricular myocardial performance index)	32(69.6%)	10(22.2%)	< 0.001

Table 3. Numerical measures data between the groups

	Case group (n=47)	Control group (n=47)	P-value
AC (abdominal circumference)	4.3 ± 1.8	38.3 ± 17.6	< 0.001
EFW% (estimated fetal weigh)	5.3 ± 2.2	42.8 ± 17.3	< 0.001
EFW (gr) (estimated fetal weigh)	1625.6 ± 502.4	2313.4 ± 552.1	<0 .001
AF (amniotic fluid)	10.7 ± 2.5	13.8 ± 2.8	< 0.001
UA PI (umbilical artery pulsatility index)	1.4 ± .3	1.1 ± .1	<0.001
UA RI (umbilical artery resistance index)	0.8 ± .1	0.7 ± .1	0.002
UA S/D (umbilical artery systolic diastolic ratio)	3.3 ± .5	2.8 ± .2	<0.001
MCA Psv (middle cerebral pick systolic velocity)	44.7 ± 6.5	41.6 ± 5.0	0.244
MCA PI (middle cerebral pulsatility index)	1.9 ± .2	1.8 ± .2	0.370
MCA RI (middle cerebral resistance index)	0.9 ± .1	0.8 ± .1	0.029
MCA S/D (middle cerebral systolic diastolic ratio)	4.8 ± .9	4.8 ± .7	0.900
UTA PI (uterine artery pulsatility index)	1.6 ± .4	1.1 ± .2	0.009
LV MPI (left ventricular myocardial performance index)	0.4 ± .1	0.3 ± .1	< 0.001
RV MPI (right ventricular myocardial performance index)	0.4 ± .1	0.3 ± .1	< 0.001

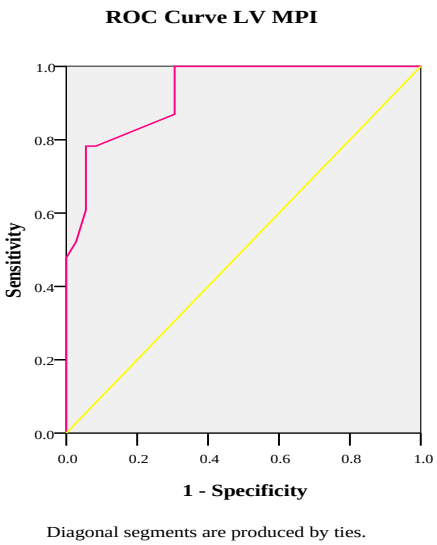

Figure 1. ROC analysis for LV MPI

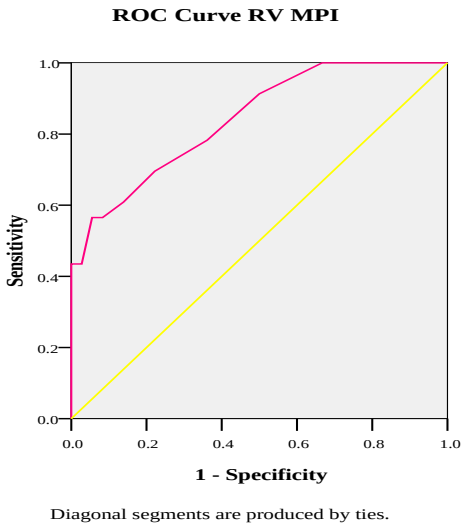

Figure 2. ROC analysis for RV MPI

Discussion

In this study, abnormal LV MPI (78% versus 11%) and abnormal RV MPI (70% versus 22%) were more common in the IUGR cases versus the control group. MPI was more sensitive than specificity, and also LV MPI was more sensitive and specific for IUGR detection. Sensitivity and specificity were 87% and 69% for LV MPI, 78% and 64% for RV MPI, respectively, to detected IUGR. Crispi *et al.* reported that a sign of cardiac adaptation to pressure overload in fetal growth restriction is post-systolic shortening by myocardial deformation **(14)**. It is a possible explanation for our findings in the current study. This study demonstrated that both mean uterine and umbilical artery PI were increased in IUGR cases. Also, the MPI was abnormal in these cases besides the global hypertrophy in such patients. Cruz *et al.* declaimed that fetal cardiovascular dysfunction in IUGR cases is a predictive index for perinatal outcomes. But our study had a cross-sectional design, and these were not evaluated in this study **(24)**. Bhorat *et al.* reported a proper predictive role for determining the myocardial performance index in the deteriorating stage of IUGR that is compatible with this study **(25)**.

It has been demonstrated that intrauterine growth restriction may impose long-term morbidities if not diagnosed promptly and accurately. Chawengsettakul *et al.* reported that fetal cardiac function by myocardial performance index has some degrees of abnormality in IUGR cases **(26)**. Another study1 by Bhorat *et al.* revealed an excellent clinical prognostic role of myocardial performance index in stable IUGR. Henry *et al.* reported good applicability of fetal MPI in assessing and managing growth-retarded fetus **(27)**.

Alici *et al.* studied 73 fetuses and found that IUGR fetuses had significantly higher MPI values, but it was not useful in predicting poor perinatal outcomes **(28)**. The low applicability of MPI was also explained by Mahsewari *et al.* for three reasons; 1) a standardized manner to the selection of cardiac time intervals used for MPI measurement is not well-known; 2) cardiac time interval calculation needs manual and subjective placement of calipers on Doppler ultrasound waveforms, and 3) ultrasound device and ultrasound system types revealed to affect the MPI measurement **(29)**. All these showed why our results are encouraging to gain attention to MPI and its applicability again. In this study, all except MCA (middle cerebral artery) indices differed between the case and the control groups; that shows it may be considered helpful to monitor for IUGR fetuses. Another current research by Patey *et al.* revealed that IUGR fetuses exhibit altered cardiac indices indicative of myocardial impairment versus normal pregnancies, reflecting adaptation to placental hypoxemia and changes in hemodynamic load in the perinatal phase, as seen in our study **(30)**.

Conclusion

IUGR fetuses have been known as a significant concern in clinical practice. This study evaluated the relation between MPI abnormalities and doppler findings in both normal and IUGR fetuses. Cardiac function was assessed by MPI in diastolic and systolic function in two groups. The results were compared to the IUGR (case group) and control group. Left and right ventricular MPI showed a significant difference statistically between the case and the control groups.

Furthermore, this study demonstrated that MPI has good prognostic value besides high accuracy, sensitivity, and relatively high specificity for predicting and evaluating the severity of growth restriction in IUGR fetuses. The study shows a significant rise in MPI in IUGR fetuses. MPI can be considered a useful parameter for evaluating the severity of growth restriction in IUGR fetuses.

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Conflict of Interest

The authors declared no conflict of interest.

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