Original **paper**

FETAL MYOCARDIAL INDEX DURING LABOR

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Abstract

BACKGROUND: The Myocardial Performance Index (MPI) is a Doppler derived myocardial function tool and can be used to evaluate systolic and diastolic function in fetuses. The objectives of this study were to investigate the MPI during labor and compare it to values in non-laboring women.

METHODOLOGY: 40 women with uncomplicated, term, singleton pregnancies were recruited to this prospective observational study at Thomas Jefferson University Hospital. Controls were a retrospective cohort of women > 34 weeks who underwent third trimester fetal echocardiography. Fetal left and right sided isovolumic contraction time, isovolumic relaxation time and ejection time were recorded before, during and after contractions. Right and left sided MPI was then calculated.

RESULTS: Laboring patients and non-laboring patients were comparable for age, race, gravidity and parity. During labor the average left MPI was 0.63 ± 0.17 and the average right MPI was 0.62 ± 0.20. The coefficient of correlation between MPI and cervical dilation was 0.15 for left MPI Index and 0.14 for right MPI. When comparing non-laboring to laboring women, the average left MPI for non-laboring women was 0.34 ± 0.04, p = <0.001.

CONCLUSIONS: Myocardial Performance Index is a non-invasive, easily attainable measure of cardiac function that can be obtained during labor and does not change with cervical dilation. MPI is significantly different between laboring and non-laboring women.

The fetal MPI may help define fetal status in labor.

Key words: *Myocardial Performance Index, Tei Index, fetal echocardiography, labor, ultrasound*

INTRODUCTION

Myocardial performance index (MPI) is a Doppler derived myocardial function tool used to assess global cardiac function. This index is dependent on myocardial function, systemic arterial and venous pressure, diastolic function, and atrial function.[1] It is not affected by ventricular size or heart rate.[2] The MPI was originally described by Tei in 1995.[2] It has been used in perinatology to evaluate systolic and diastolic dysfunction in fetuses with twin to twin transfusion syndrome, preterm premature rupture of membranes, fetal anemia and intrauterine growth restriction.[3-9] Additionally, MPI has also been used to evaluate cardiac function in fetuses of diabetic mothers and in fetuses with arrythmias.[10-14] Many of these studies have found significant increases to MPI in these fetuses.[3-12]

There is very little information available about MPI in term fetuses in labor. Labor can be a potentially stressful environment for a fetus and hypoxemia and even acidosis may occur. This sequence may affect fetal cardiovascular status, as manifested by progressive loss of beat-to-beat variability and heart rate decelerations. It is possible that these physiological changes manifest as a difference in fetal MPI.

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The objective of this study was to investigate the feasibility of assessing MPI during labor of normal term pregnancies, to establish normative values and to evaluate change with cervical dilation. Primary outcome was establishment of normal MPI values during labor. Secondary outcomes were the change in MPI with cervical dilation and the comparison between MPI values of laboring and non-laboring women.

METHODS

This was a preliminary prospective observational study with a retrospective control group based at Thomas Jefferson University Hospital. All women with low-risk

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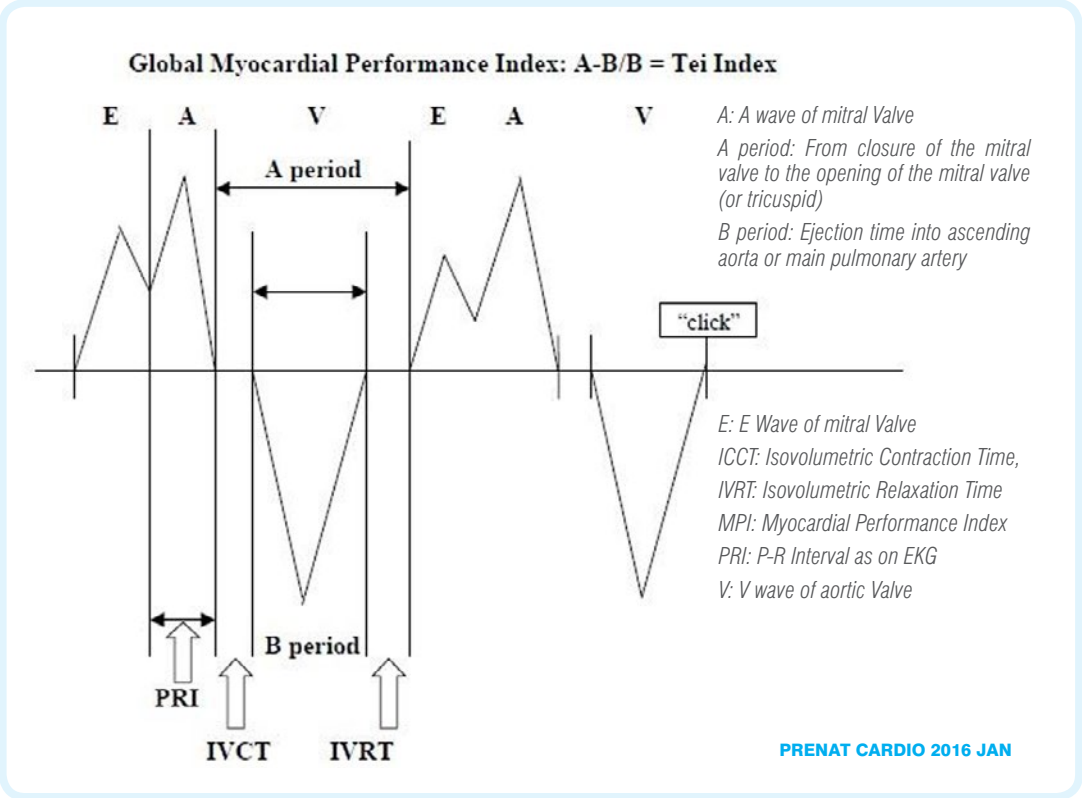

Figure 1: Graphical Representation of MPI

pregnancies (those with no maternal or fetal concerns identified in the antenatal period), in labor, with category 1 or 2 fetal heart tracings were considered eligible for inclusion.

Labor was defined as regular, painful contractions associated with cervical effacement and or dilatation. Controls were a retrospective cohort of women > 34 weeks who underwent third trimester fetal echocardiography and were identified by ultrasound

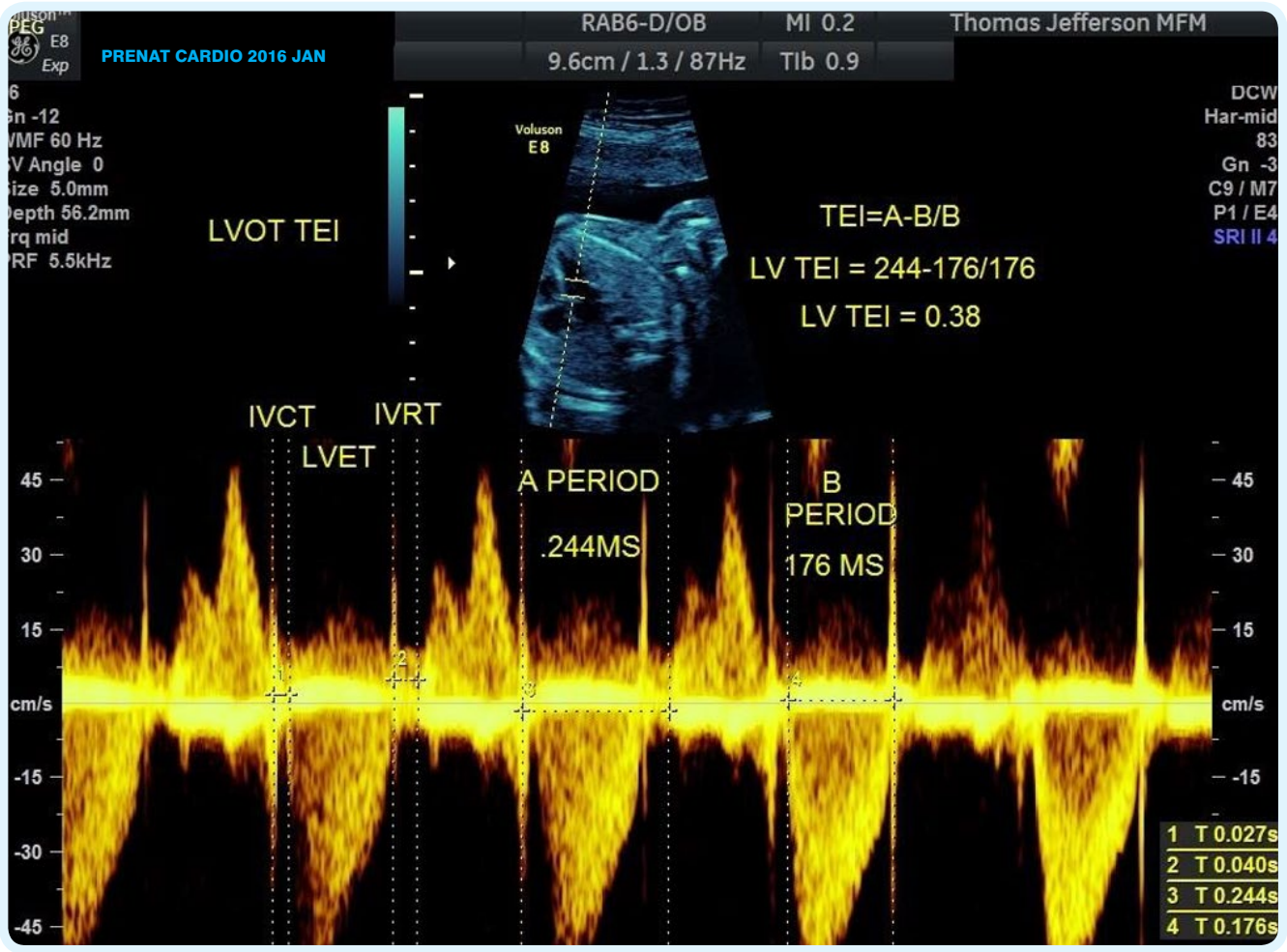

Figure 2: Ultrasound Image of MPI

Patient Demographics	Non-Laboring n= 20 Mean ± SD	Laboring n= 20 Mean ± SD	P value
Age (years)	26.3 ± 6.0	29.2 ± 5.7	0.18
Gestational Age (weeks)	35.5 ± 1.4	39.8 ± 1.0	<0.0001
Gravidity	3.1 ± 1.9	4.1 ± 3.0	0.12
Parity	1.3 ± 1.2	1.4 ± 1.2	0.70
Mean BMI at delivery	35.6 ± 8.0	32.9 ± 5.0	0.22
Race			0.10
Non-Hispanic white (n, %)	4 (40%)	10 (50%)	
Non-Hispanic black (n, %)	12 (60%)	4 (20%)	
Asian (n, %)	0 (0%)	4 (20%)	
Other (n, %)	0 (0%)	1 (5%)	
Diabetes (n, %)	6 (30%)	2 (10%)	0.11
Hypertensive disorder (n, %)	3 (15%)	4 (20%)	0.68
Maternal drug use	3 (15%)	0 (0%)	0.07

Abbreviations: SD- standard deviation

Table1: Maternal Obstetric Characteristics

records. Indications for echocardiography included maternal diabetes or difficulty visualizing the fetal heart at time of anatomy ultrasound.

Exclusion criteria were multiple pregnancy, non-cephalic presentation, scheduled cesarean delivery and known fetal anomaly. Women were recruited on the labor and delivery floor over a 5 month period, shortly after admission. Each patient gave written consent for inclusion in the study. Patient demographics such as age, ethnicity, and parity were recorded.

Women then underwent an ultrasound assessment in which fetal MPI index was assessed. All ultrasound scans were performed by a single operator using the Zonare machine (z.one SmartCart Diagnostic Ultrasound System, Mountain View, CA) and a trans-abdominal curvilinear transducer, specifically C6-2. Participants were positioned in a supine position, with a left lateral tilt to avoid vena caval compression.

For MPI assessment in the laboring group, Doppler was used to obtain right- and left-sided cardiac isovolumic contraction time (ICT), isovolumic relaxation time (IRT), ejection time(ET) and fetal heart rate(FHR) from the apical four-chamber view (Figure 1 and 2). By sweeping the probe apically, the origin of the aorta and the mitral leaflets can be visualized. For the left MPI, the Doppler gate was placed in the internal leaflet of the mitral valve. For the right MPI, Doppler gates were placed in the tricuspid and pulmonary valves in two separate planes. Readings were taken before, after and during uterine contractions and were repeated 3 times, with the mean value being used for data analysis. In the non-laboring group MPI was measured on the left side only.

The IRT, ICT and ET were then used to calculate MPI index.

The following formula was used for calculation: MPI index= (ICT + IRT) /ET^2. Cases were then managed according to hospital protocols and guidelines. Labor and delivery staff were blinded to the results of the ultrasound to confirm that the ultrasound findings did not influence obstetric management.

Statistical analysis was performed with Anova test or student t-test. P value of <0.05 was considered significant. This study was approved by the Thomas Jefferson University Institutional Review Board.

RESULTS

Baseline characteristics

20 patients were recruited to the prospective cohort and 20 patients were identified retrospectively as controls. Demographics were similar in the control group and the labor group. Gestational age was significantly different between the two groups (Table 1). Mean fetal heart rate was 135.5 beats per minute.

MPI

The average left MPI during labor in term fetuses was 0.63 ± 0.17. The average right MPI during labor was 0.62 ± 0.20. MPI was not different between right and left sides (p=0.5) or with timing of contractions (p= 0.4 right MPI, p= 0.8 left MP, Table 2).

The correlation coefficient between MPI and cervical dilation was 0.15 for Left MPI Index and 0.14 for Right MPI (Figures 3 and 4).

Compared to laboring women, the average left MPI in non-laboring women was 0.34 ± 0.04, p = <0.001(see Figure 5).

DISCUSSION

Normal MPI values have been established throughout gestation.[15] Values at term have ranged from, 0.36 -0.55[15-19]. Studies suggest that MPI increases over gestation.[16] Feasibility, change with contraction timing and normative values for fetuses during labor were evaluated in this preliminary study. Feasibility has been

	Before contraction	During contraction	After contraction	Average	P value
Average Right MPI Mean ± SD	0.63 ± 0.08	0.63±0.12	0.60±0.08	0.63±0.20	0.4
Average Left MPI Mean ± SD	0.61± 0.09	0.61±0.09	0.65±0.07	0.64±0.17	0.4

Table 2: MPI values

Abbreviations: SD- standard deviation

previously evaluated and MPI can be readily taught and reproduced during prenatal ultrasound in the antepartum period.[2,15] As demonstrated in this study, MPI is possible to be obtained during labor. Of all patients who were approached and consented, MPI was attainable100% of the time.

In this study we evaluated the right MPI and left MPI both separately and together. When compared, the right and left MPI measurements were not significantly different. As both sides did not differ, we suggest that only fetal left MPI needs to be measured in future work because it is technically easier to obtain.

We hypothesized that as labor progresses there may be more stress on the fetal heart, which could result in a change of MPI. However, MPI was stable across cervical dilation as can be seen in Figures 3 and 4. This may be useful background information as MPI may be able to be assessed in forthcoming studies as a possible predictor of fetal compromise during labor.

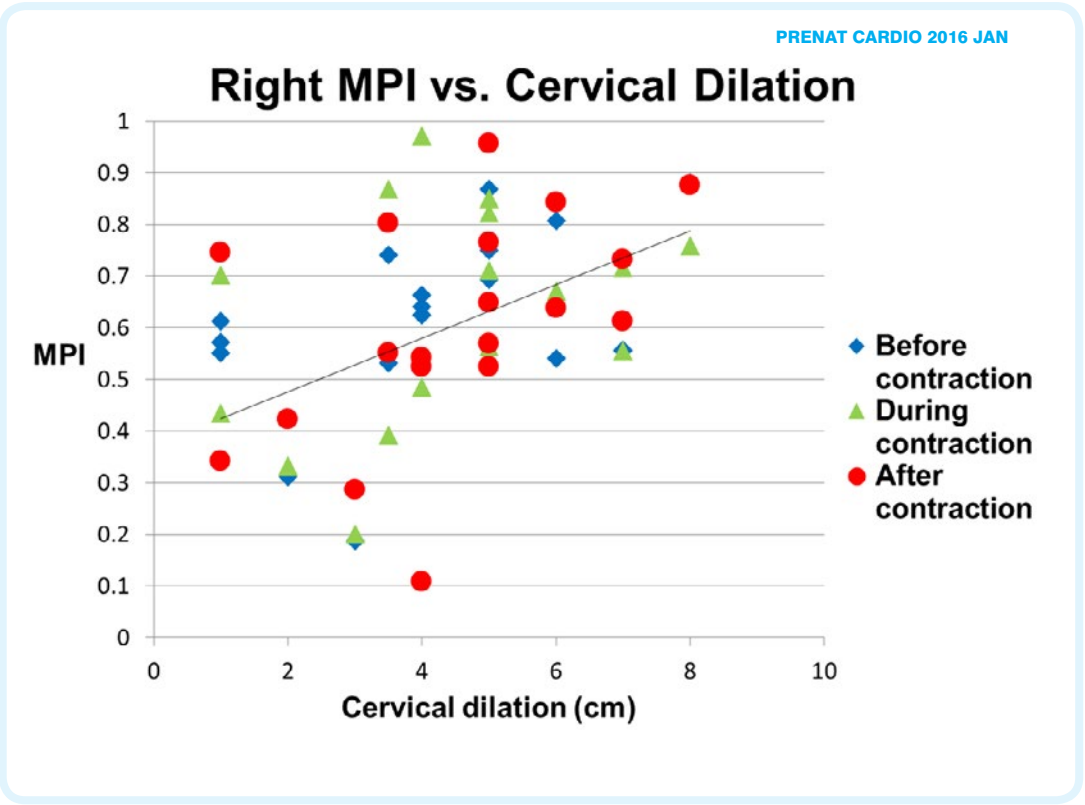

Figure 3: Right MPI vs Cervical Dilation

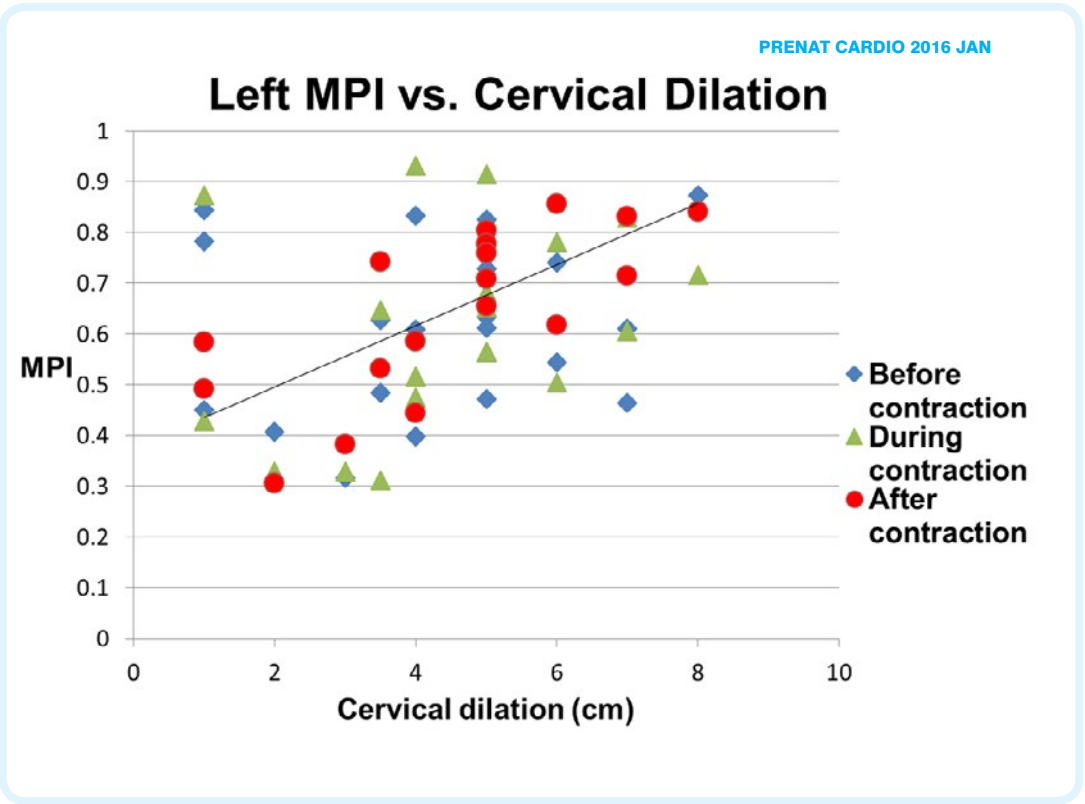

Figure 4: Left MPI vs. Cervical Dilation

We theorized that the MPI would vary with the timing of the contractions because fetal heart rate deceleration patterns differ with timing of contraction and have different

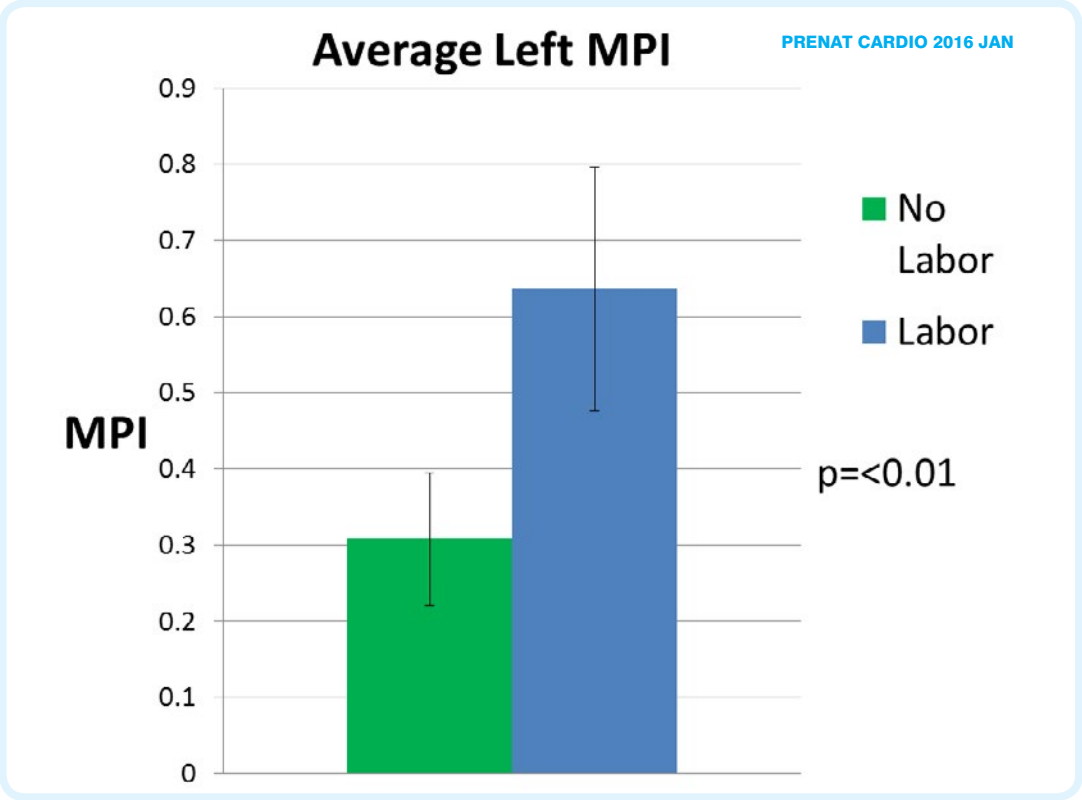

Figure 5: Average MPI During Labor Compared to No Labor

pathophysiological explanations. However in this study, the MPI did not change with contraction timing. This could be attributed to the fact that heart rate does not affect MPI since MPI is a calculated ratio.

The overall average value of the MPI that we measured during labor was 0.63. This is slightly higher than values obtained in the literature in the third trimester and in our retrospective control group.[9, 15-17] An explanation could be the small patient sample. However, this also could be explained pathophysiologically as a fetus during labor has a more demanding environment on cardiac physiology than a fetus outside of labor. Previous studies have noted increased MPI in babies of diabetic mothers, PPROM and IUGR, which are also representative traumatic fetal conditions. In some of these reports increased MPI has also been associated with adverse perinatal outcomes such as perinatal death, 5 minute Apgar, neonatal acidemia and cardiomyopathy.[4] The environment of labor could be shifting the global cardiac physiology in a similar fashion.

We cannot conclude definitively from this study that these MPI values are elevated as this is a preliminary study. However, it will be important to validate this data for future applications of MPI in labor. Future applications could be relationship to FHR, fetal hypoxemia and neonatal outcomes.

Limitations include the small study size and the observational study design. An additional limitation was that the control group had retrospective data only and because of that only left MPI was able to be obtained as a comparison. Additionally, maternal diabetes was the most likely indication for fetal echocardiography in the control group, which is known to increase the MPI[11-13].

In conclusion, myocardial Performance Index is a non-invasive, measure of cardiac function that can be readily obtained during labor, and does not change with labor. The fetal MPI may help define fetal status in labor.

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