Evaluation of the Fetal Myocardial Performance Index in Abnormal Cardiotocography Cases in 3rd Trimester of Pregnancy and Fetal Outcome

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Abstract

Background: Cardiotocography is broadly used, particularly in pregnancies with an elevated probability of risks, to assess fetal well-being. The study's objective was to evaluate the accuracy of the myocardial performance index (MPI) in predicting fetal distress in pregnant women with unsatisfactory cardiotocography. **Methods:** This prospectivestudy included 145 women in late pregnancy divided into two groups: Cases (n=72) including women with abnormal cardiotocography and Controls (n=73) including women with normal cardiotocography. **Results:** The MPI significantly increased in cases compared to control groups (0.46 vs. 0.38, p<0.001). In heatmap correlation, the MPI remained a significant negative correlation with Apgar score At 1 and 5 min., acceleration, and variability, whilethe positive correlation with ET, FHR, deceleration, and mode of delivery. A cut-off MPI of ≥0.51 conferred a specificity of 71.23 %, sensitivity of 65.28 %. **Conclusion:** MPI measurement during the third trimester is a promising surrogate marker for abnormal cardiotocography (CTG) and fetal distress. Women with abnormal cardiotocography (CTG) had significantly higher MPI and worse fetal outcomes.

Keywords*: Cardiotocography, fetal Myocardial Performance Index, 3rd Trimester, fetal pregnancy outcome.*

Introduction

In the antennatal phase, there is little reason to suggest that female follow-up with high-risk pregnancy helps the mother or infant, but research on this is old and should be considered with caution. However, computerized echocardiography (CTG) machine contributed to fewer baby deaths than conventional CTG machines. More up-to-date studies are required to include more knowledge about this practice[1].

An electronic transducer directly connected to the fetal scalp is used in internal cardiotocography. The wire electrode is placed via the cervical opening on the fetal scalp and wired to the computer. This kind of electrode is often referred to as a scalp or spiral electrode. Internal monitoring gives a fetal heart rate transmission that is more precise and accurate than external monitoring, so conditions as a movement do not affect the fetal heart rate[2].

Fetal CTGhas been applied for non-invasive examination of human fetal heart anatomy, activity, and hemodynamics. The Myocardial Performance Index (MPI), a Doppler index of combined systolic and diastolic ventricular MPI, has been suggested as a theoretically valuable indicator of global heart rate that does not affect ventricular geometry and heart rate[3]. The MPI index is computed as a total of isovolumetric relaxation time (IRT) and of the isovolumetric contraction time (ICT) segmented by the time of ejection (ET)[4].

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The impaired cardiac activity of fetuses in the third trimester is well documented. Increased myocardial performance index signaling deterioration of global myocardial performance in limited numbers of fetuses of mothers in late gestation has been identified

Figueroa, Silva[5]showed a small rise in MPI in the fetuses of diabetic mothers, and therefore MPI values can not predict complications for newborns. The increase in MPI was attributed to a reduced ejection period and an improvement in isovolumetric relaxation time, thereby representing global myocardial dysfunction. In a diabetic mother's fetus, impaired ventricular compliance has also been identified, culminating in diastolic dysfunction.

This research aims to evaluate the accuracy of the myocardial performance index (MPI) in predicting fetal distress in pregnant women with non-reassuring cardiotocography in the third trimester.

Subjects and Methods

This prospective cross-sectional study was conducted on 145women in late pregnancy (30-40 weeks gestation) attending the Ultrasound Special Care Unit for the Fetus-Maternity Hospital, Ain Shams Maternity Hospital, during the period from 1st January 2018 to 1st September 2019.

Eligible women were divided into two groups; 1-Cases,including women with abnormal cardiotocography, and 2-control, including women with normal cardiotocography.

The study included pregnant females between 30 and 40 weeks gestational age (GA) in a singleton fetus; In the cases group, women with suspicious cardiotocography warrant action to correct reversible causes if identified, close monitoring, or adjunctive methods. In contrast, women with multiple pregnancies, congenital fetal malformation, and reassuring cardiotocography were excluded from the study.

Study procedures:

The following data were collected: detailed history thorough general and local examinations, investigations; external cardiotocography, 2D transabdominal ultrasound (Samsung WS 80 with Elite, V.2), mode of delivery, and APGAR score.

The technique of MPI calculation:

Fetal echocardiography was conducted on each pregnant woman using the Samsung WS80A ultrasound system (Medison, Korea). The MPI of the left fetal ventricle was estimated as initially described byHernandez-Andrade, Figueroa-Diesel[6]. A cross-sectional view of a cardiac apical 4-chamber image was acquired. The Doppler sample was located at the ascending aorta's medial wall, including the leaflet of the mitral valve (MV) and aortic valve (AV). Opening and closing of MV and AV clicks were imaged. The angle of insonation was <30°. The Doppler gain was lowered enough to identify the echoes, clearly marking the MV and AV clicks' opening and closing. The Doppler sweep speed was set at 540 Hz, scale at 55 cm/s, and wall motion filter at 100 Hz. The following three periods were calculated: isovolumic contraction time (ICT) from MV closure to AV opening, isovolumic relaxation time (IRT) from AV closure to MV opening, and ejection time (ET) from AV opening to closure. Therefore, the MPI=(ICT+IRT)/ET.

Statistical Analysis

All data were statistically analyzed using version 26 of the SPSS (Statistics Package for Social Science). The rank correlation of Heatmap Spearman was calculated to assess the correlation between MPI value and Fetal U/S, CTG parameters, and Neonatal outcome.

Quantitative data with non-parametric distribution were done using the analysis of variance Mann Whitney test to comparison between two groups, and the t-test was used for parametric comparisons between two groups. The Chi-square (x^2) test has been used to compare qualitative variables. The receiver operating characteristic curve (ROC) was used to assess the best cut-off point with its specificity, sensitivity, and area under the curve (AUC) done by using Medcalc (version 15.80)[7].

Results

The meanage of the 145 females was 30.33± 4.47,and the gestational age of the 145 females was 36.32 ±1.86weeks. The results presented in the succeeding text are based on 72 cases and 73 controls. The mean age and

gestational age obtained were all no significant difference between cases and controls group. There were also no significant changes between groups (cases and control) regarding a medical disease (Table 1).

Table (1): Comparison between cases group and controls group according to baseline characteristics.

Baseline characteristics		**Cases group (n=72)**		**Controls Group (n=73)**		**Significant test**	**p-value**
Age (years)	Mean ±SD	30.40±4.94		30.26±3.99		0.189*	0.850 ns
Parity	Median (IQR)	3 (2-3)		3 (2-3)		2455.00#	0.482 ns
Gestational age (wks)	Mean ±SD	36.68±1.75		35.96±1.90		1.675*	0.091 ns
		N	%	N	%	Chi square	p-value
Medical disease	DM	15	20.8%	13	17.8%	2.162	0.826 ns
	HTN	19	26.4%	15	20.5%		
	IUGR	8	11.1%	8	11.0%		
	PP	11	15.3%	10	13.7%		
	PROM	8	11.1%	10	13.7%		
	Free	11	15.3%	17	23.3%		

*; t-test, #; Mann Whitney; IQR, interquartile range; Ns; non-significant at p >0.05

According to Fetal U/S parameters, The median ET and MPI were significantly higher in cases compared withcontrols (200.34vs.183.10,p<0.001 at ET) and (0.46 vs. 0.38, p<0.001 at MPI), as shown in Figure 1. The median Neonatal outcome (Apgar score At 1 min and 5 min) ere significantly different between the two groups (Figure 2).

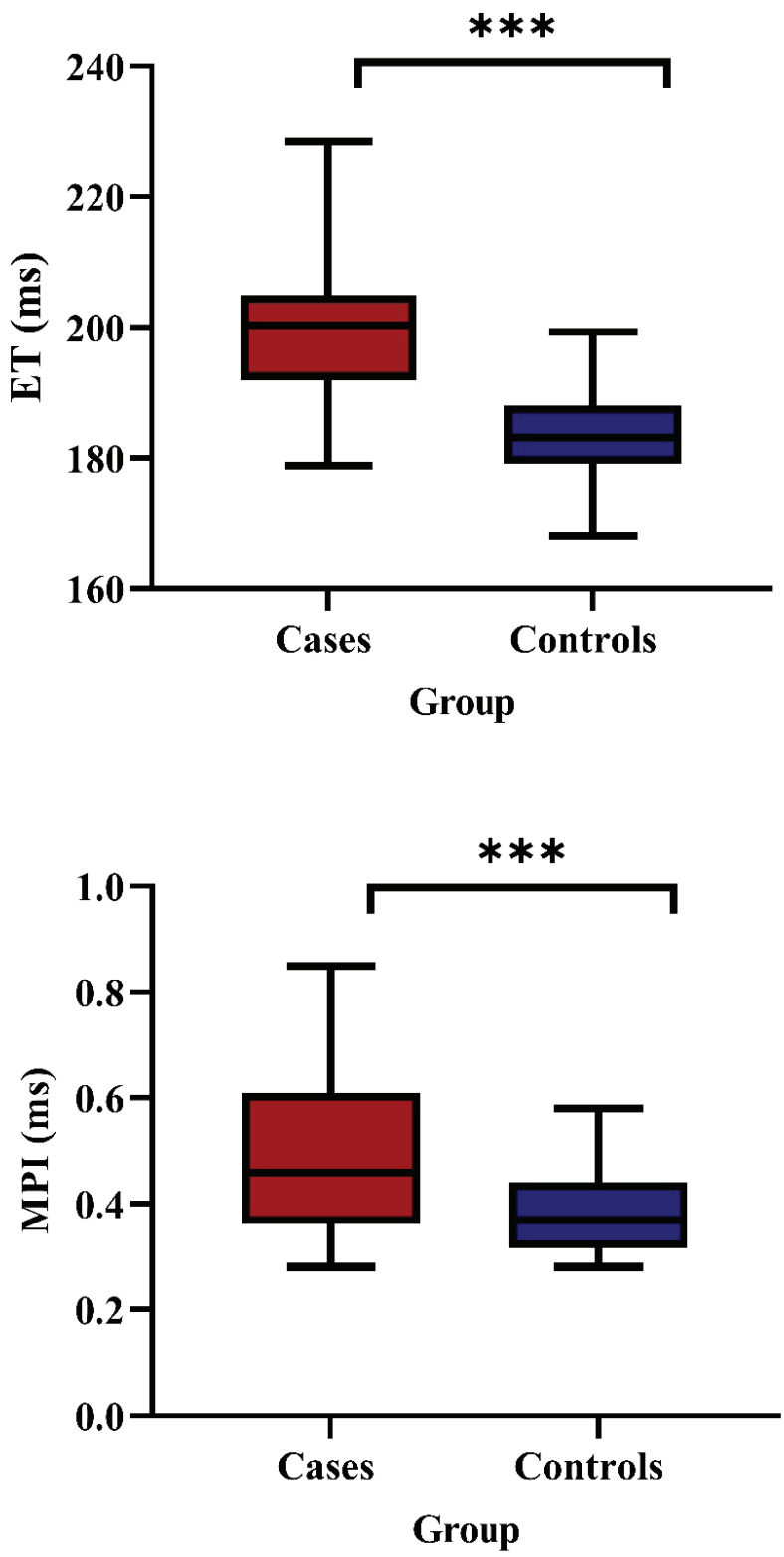

Figure (1): The boxplot compares the cases and control groups according to fetal U/S parameters. *; highly-significant at p < 0.001**

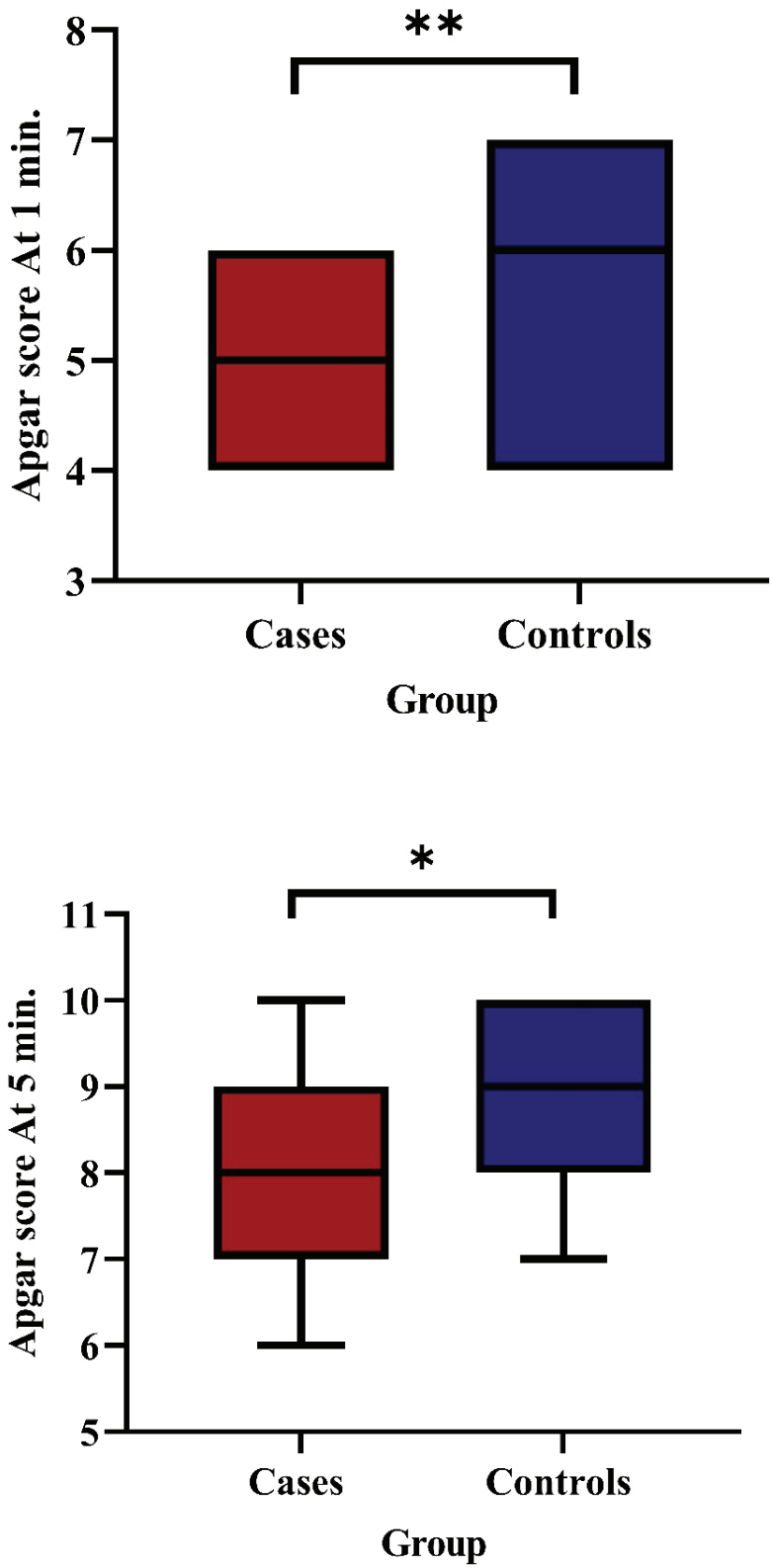

Figure (2): The boxplot compares the cases and control groups according to the neonatal outcome. *, **; significant at p < 0.05

There wasa significant increase in FHR in cases compared with controls (Figure 3). The variability, acceleration, and deceleration distribution were significantly different between the two groups (Table 2).

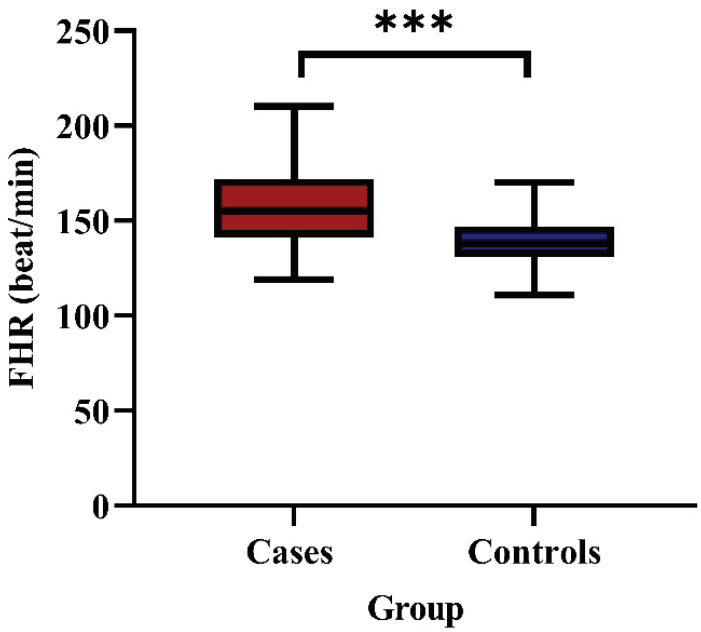

Figure (3): The boxplot compares the cases and control groups according to fetal U/S parameters. *; highly-significant at p < 0.001**

Table (2): Comparison between cases group and controls group according to CTG parameters

; significant at p < 0.05, *; significant at p < 0.01

CTG parameters		Cases group (n=72)		Controls Group (n=73)		Chi-square test	p-value
		N	%	N	%		
Variability	Decrease	42	58.3%	0	0.00%	59.947	<0.001**
	Normal	30	41.7%	73	100.0%		
Acceleration	Absent	60	83.3%	0	0.00%	103.77	<0.001**
	Present	12	16.7%	73	100.0%		
Deceleration	Absent	64	88.9%	73	100.0%	8.585	0.003**
	Present	8	11.1%	0	0.00%		

There was a significant negative correlation between the MPI value and the Apgar score at 1 min., and 5 min., acceleration and variability. While the positive correlation between the MPI and ET, FHR, deceleration, and mode of delivery (Figure 4).

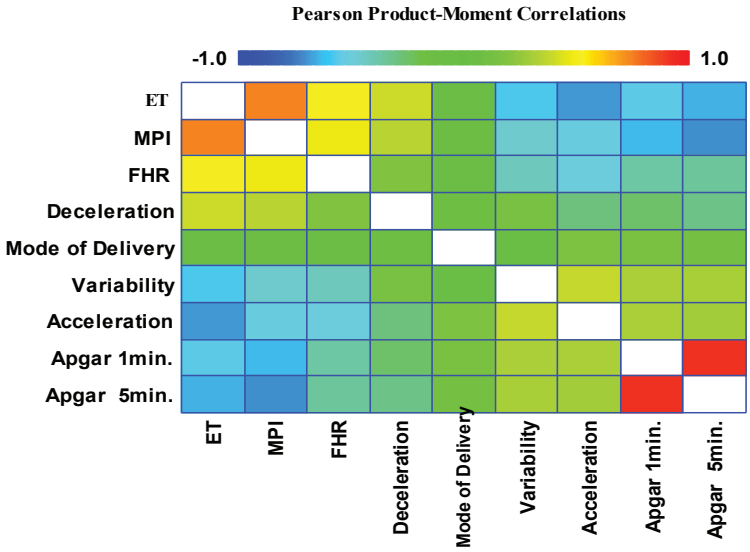

Figure (4): Heatmap spearman Spearman's correlation coefficient show correlation between MPI and fetal U/S, CTG parameters, and Neonatal outcome

The specificity and sensitivity of each MPI to predict perinatal death (Figure 5). The ROC area under the curve (0.73) andthe cut-off MPI ≥ 0.51 provide a specificity (71.23%), a sensitivity (65.28%).

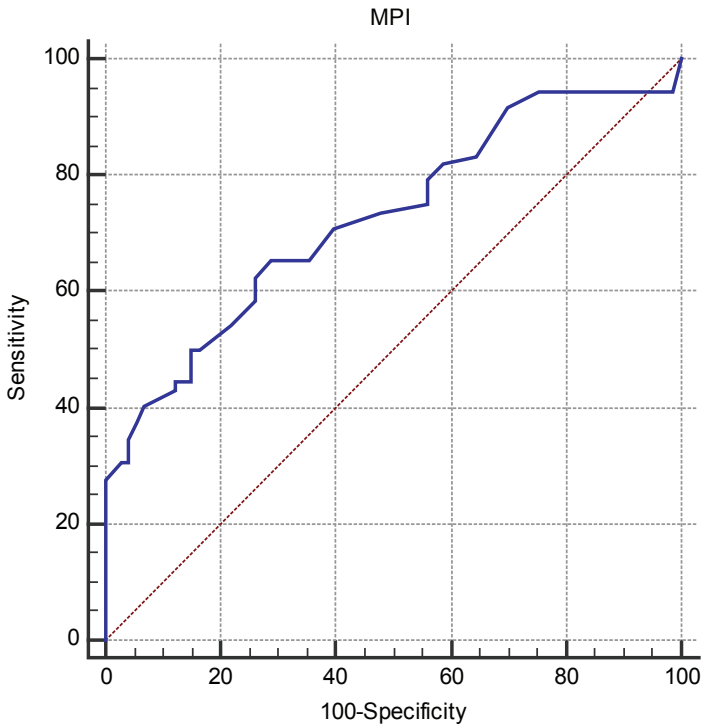

Figure (5): Receiver operating characteristic (ROC) curve: the significant relationship between myocardial performance index cases and myocardial performance index control (area under the curve of 0.726)

Discussion

A significant problem has long been the production and perfection of specific and precise diagnostic tests for recognizing the fetus at risk in the uterus. Since more than 75% of fetal deaths arise during the antepartum era, the emphasis has changed from restricting fetal monitoring to the antepartum period. Initially, monitoring fetal heart rate began to diagnose fetal hypoxia or fetal acidemia, triggering multiple-organ problems in the infant. Intrapartum or early neonatal death may be the severe consequences of this trauma. The lower intensity of hypoxia may contribute to transient or potentially permanent morbidity[8].

Trace CTG was used as a screening tool to prevent permanent hypoxic damage to fetuses undergoing intrapartum hypoxic tension. However, according to recent reviews, CTG is correlated only with decreased rates of neonatal seizures but not with cerebral palsy, perinatal mortality, or other predetermined neonatal well-being interventions. Moreover, it is not possible or advisable to use continuous CTG in limited-resource environments[9].

Functional cardiac assessment using echocardiography is increasingly valued because it detects subtle myocardial dysfunction during growth and can guide treatment and improve neonatal results[10].

Despite the growing interest in the role of MPI in the prediction of neonatal outcomes, little is known about its role among women with non-reassuring CTG. Thus, the present study was conducted to determine the accuracy of MPI in predicting fetal distress in pregnant females with non-reassuring CTG in the third trimester.

Existing evidence suggests a significant correlation between pathological CTG and the state of the newborn assessed by Apgar score, the existence of acidosis, hypoxic-ischemic encephalopathy, and subsequent neuromotor development[11]. In our cohort, women with abnormal CTG had significantly lower Apgar scores. No association was found between abnormal CTG findings and mode of delivery.

In agreement with our findings, Bogdanovic, Babovic[11] in the study pathological CTG records were found to be associated with lower Apgar scores.

Similarly Sultana, Chowdhury[12],in a prospective study, lower Apgar score was associated with abnormal CTG.

Najam, Gupta[13]performed a prospective observational study on 150 gravid women with high-risk pregnancies. This study concluded that CTG reactivity and low Apgar score played a statistically important role. ($P< 0.001$).

While Grivell, Alfirevic[1] evaluated the efficacy of prenatal CTG in enhancing mother's and babies' results during and after birth and included six research (including 2105 women) in this study. Overall, in cesarean sections or secondary outcomes, no significant variation was found.

That woman with abnormal CTG had significantly higher MPI and ET. In addition, there were highly statistically significant differences between groups (cases and control) in terms of FHR, variability, acceleration, and deceleration ($p < 0.001$).

Our study is the second study of its kind that evaluated the correlation between MPI and abnormal CTG findings to the best of our knowledge. Contrary to our results, Gimovsky, Whitney[14] considered whether the left MPI alteration is correlated with FHR tracing. Twenty-four females with term, singleton pregnancies were volunteer to this study. MPI was not substantially different for Category I or II FHR fetuses. In addition, MPI was not significantly different for fetuses without or with deceleration, between the method of deceleration, or between the types of heterogeneity.

The exact causes of such heterogeneity between our findings and the abovementioned study are unclear. However, it can be attributed to many methodological differences. Gimovsky, Whitney[14] noticed no significant difference concerning MPI between Category I and II fetal heart tracing. One potential cause is that FHR Group I does not distinguish fetuses at risk of fetal acid-base decompensation adequately versus II. This may be attributed to Category II perception of fetal status as "indeterminate." However, there is usually no evidence of compromise at birth, so the MPI will be required to stay

unchanged between Group I and II FHR. An additional explanation can beGimovsky, Whitney[14]study.

Regarding the predictive value of MPI during the third trimester, we found statisticallysignificant differences between women with abnormal and normal MPI in terms of Apgar score at 1 minute and 5 minutes ($p < 0.001$).

In agreement with our findings, Zhang, Han [10]studied MPI shifts in late and early-onset fetal growth restriction (FGR) cases and their correlation with detrimental perinatal outcomes.This study on 100 cases of late-onset and 77 cases of early-onset FGR. Adverse effects in late-onset FGR (OR =3.412) and early-onset FGR (OR =3.307) were correlated with MPI.

On the contrary, Ozel, Alici Davutoglu[15]measured the prognosis of the importance of MPI for adverse perinatal outcomes. The MPI was studied in 73 fetuses. There was a highly significant negative correlation between the MPI and a 5-min Apgar score.

The sensitivity and specificity of each MPI cut-off to predict perinatal death are shown in Figure 7. The area under the curve of ROC (0.73) and a cut-off MPI of ≥ 0.51 gives a Sensitivity (65.28 %), specificity (71.23 %). This analysis indicates that more than ≥0.54 of the mod-MPI values predict adverse outcomes[6]. The potential reason is that there may be a fetal reserve that causes the coping buffer zone to be increased between the 95th percentile and MPI levels shown before adverse results are determined. Extreme results were correlated with MPI degradation.This will be consistent with the research by Crispi, Hernandez-Andrade[16], which showed biochemical proof of myocardial cell disruption (increased heart-fatty acid-binding protein and B-type natriuretic peptide) with a hemodynamic compromise of FRG.

Our study also showed that the MPI was irregular at the early stage of the growth-restricted phase, allowing the clinician to monitor the growth-restricted fetus's cardiovascular degradation.

Hernandez-Andrade, Figueroa-Diesel[6]illustrated that the MPI was separately correlated with perinatal mortality and then used the MPI >95thpercentile for reference abnormality rather than the actual specific cut-off values.

Conclusion

MPI measurement during the third trimester is a promising surrogate marker for abnormal CTG and fetal distress. The present study showed thatwomen with abnormal CTG had significantly higher MPI, while abnormal MPI was significantly associated with fetal outcomes. The MPI is readily available, reproducible, and can be incorporated into a routine ultrasound scan, which adds importance to the fetal assessment. However, further well-designed studies are still needed to confirm our finding.

Ethical Clearance- Taken from department of Obstetrics and Gynecology department, the Faculty of Medicine, Ain Shams University Committee. The study was registered online at clinicaltrials.gov (NNCT03638245).

Source of Funding- Self

Conflict of Interest - Nil.

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