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Modified Left Ventricular Fetal Myocardial Performance Index: A Case-Controlled Study

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Abstract

Background: Modified left ventricular fetal myocardial performance index (MPI) is a pulse wave Doppler index that can be utilized to assess global fetal myocardial function . Fetal MPI is handily performed non- invasive method for the assessment of foetal cardiovascular well-being. Aim: This study aimed to access normal values for foetal modified left ventricular (LV) MPI and its correlation with heart rate and gestational age among foetuses in central India.**Material and Methods:**In our study, total seventy-one singleton pregnant women with normal pregnancy were included. The Mod-LV MPI was calculated as the ratio of sum of the isovolumetric constriction time (ICT) and isovolumetric relaxation time (IRT) upon ejection time (ET). MPI = ICT+IRT/ ET. We also assessed correlation of MPI with foetal heart rate and gestational age.**Results:**The normal mean MPI of second and third trimester foetuses of Indian population was 0.409±0.052. Mean ICT was 45.7 ± 7.0ms, mean IRT was 55.9 ± 6.7ms, and mean ET was 148.2 ± 10ms. The mean FHR was 142.26 ± 5.8 bpm and mean gestation age (weeks) is 33.16 ± 4.8. The coefficient correlation analysis reveals MPI is independent of both gestational age and FHR.**Conclusion:**Our study gives the normal range of MPI in the normal heart foetuses of the Indian population and it also shows that MPI is independent of gestational age and FHR. Thus, MPI ought to be utilized for the underlying initial assessment of the foetal heart and babies with congenital heart defect just as for the follow up of foetuses with a heart defect. MPI is additionally conceivably helpful for evaluation the foetal cardiac status in noncardiac disease state.

Keywords: Myocardial performance index (MPI), Cardiac time intervals, Foetal cardiac function, Isovolumetric contraction time (ICT), Isovolumetric relaxation time (IRT).

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Introduction

Routine foetal cardiovascular examination mainly includes morphological evaluation by a four-chamber view, 3VV and outflow tract examination. In this era of advance imaging, morphologically focused foetal cardiac examination is not sufficient, it ought to incorporate functional and hemodynamic assessment of the foetal heart. In current scenario, cardiac functional assessment is being done through ejection fraction and ventricular inflows but these parameters detect ventricular dysfunction in somewhat later stage. By incorporating functional and hemodynamic cardiac parameters like “myocardial performance index” in foetal cardiac surveillance, early detection can forestall the progression of intrauterine cardiac failure in various diseases.

Myocardial performance Index MPI or Tie index was first reported as a measure of global myocardial function in 1995.[1]MPI is a handily performed, non-invasive, pulse wave Doppler index that can be utilized to assess global myocardial function in a significant method for the assessment of foetal cardiovascular well-being.[2]

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The index comprises both systolic and diastolic components, and can be used to analyse each ventricle independently. It has the advantage of not requiring a detailed anatomical survey in order to analyse function.

The Mod-LV MPI is the ratio calculated by addition of the isovolumetric contraction time (ICT) and isovolumetric relaxation time (IRT) upon ejection time (ET).

$$MPI = ICT + IRT / ET$$ [3]

Normal value ranges from 0.30 to 0.53(with reference to previously published studies).

Both atrioventricular and ventricular ejection flow are assessed to decide constituent time interval.[4]

- The isovolumetric contraction time (ICT) is the early systolic phase of cardiac cycle, in which ventricle constriction increases the intraventricular pressure without corresponding changes in ventricular volume (isovolumetric) since all valves are shut during this stage.
- The isovolumetric relaxation time (IRT) is the short interval in cardiac cycle, which start from closure of aortic valve and it ends as filling through AV valve starts. During this phase of cardiac cycle, post systolic myocardial relaxation occur without changes in ventricle volume (isovolumetric), result in diminishing of intraventricular pressure since no blood is entering or leaving the ventricles.[5]
- The ejection time (ET) is the time interval between opening and closing of the aortic/ pulmonary valves, during which myocardium contract to push blood out from the ventricle.[6]

Ventricular dysfunction is related to higher MPI values, usually IRT interval is the first parameter that get prolonged in the beginning cardiac dysfunction, IRT interval prolongation is caused by diminished calcium uptake via cardiac myocytes.An increased IRT is commonly followed by decreased ET, while ICT is nearly the most stable MPI parameter.

MPI or Tie index has been used in paediatric and adult echocardiography since decades, so it can be equally beneficial in foetal echography, so as to detection and prevention of cardiac failure in early stages.

It is a valuable technique for assessing foetal cardiac changes in complicated pregnancies, for example, IUGR, maternal diabetes, twin-twin transfusion condition, congenital cardiac abnormalities, pre-eclampsia, and so on. MPI helps in recognizing the high-risk population (those having higher MPI values) that help in early therapeutic intervention which lessens perinatal mortality.

This study aimed to know normal values for foetal modified left ventricular (LV) MPI and its correlation with heart rate and gestational age (weeks) among foetuses in central India.

Material and Methods

This was a hospital-based, prospective observational study. The study was led in the USG section, at Tertiary care teaching Hospital over a period of 1 year.

An overall seventy-one singleton pregnant ladies without any complication were enrolled for the study. Pregnant ladies with a singleton pregnancy who were alluded to the USG section of the Radio diagnosis dept. for their scan at 20–40 weeks of pregnancy, and who are ready to take part were included for the examination.

Inclusion criteria:

All pregnant women with a singleton pregnancy between 20–40 weeks of pregnancy, ready to take an interest in the examination were included for the investigation.

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Exclusion criteria:
Those who are not interested to take part in the examination, having multiple pregnancies, and related to certain complications with it were not taken in.

Apparatus used:
Assessment was done with 2.5–5 MHz transducer on the USG Wipro GE Voluson S6 pro-USG machine accessible in the department of Radiodiagnosis.
After doing formalities case were taken for the examination and scan was done carefully. A predesigned, approved, and pre-tested proforma was utilized to gather required data. After level 2 scan foetal echo was done and all required parameters were recorded.

Scan technique[7,8]
It is important to have a clear identification of method to measure the MPI. Overtime there are modifications by Friedman et al and others [3]. To have a better method to do it, we in our study follow the technical guideline by Hernandez-Andrade et al. Recordings must be performed by the 4-chamber view of the heart with an apical projection and an angle of insonation below 20°. The transducer is slightly displaced in the cranial direction where the mitral and aortic valves are visible. A sample gate of about 3–4 mm is placed, including the leaflets of both valves. Fastest Doppler sweep velocity of 15 cm/sec used to better define intervals with low Doppler gain. A high wall motion filter of 200-400 hertz was used. It is recommended to reduce the gain to exclude noise and artefacts, and to increase the speed of the Doppler baseline to the maximum for clear identification of the anatomical landmarks and time components of the waveform. High wall motion filter (WMF) must be set to avoid recording of slow blood movements and to clarify time intervals. Alteration of both angle of insonation and WMF have been found to influence the reproducibility of time interval measurements.[9] Clear valve clicks must be observed in order to correctly place the time cursors.

Statistics Analysis:[4]
SPSS 20 version was used for the statistics analysis. All numeric data are expressed as mean ± SD. Linear regression analysis were used to see any relation between MPI and gestational age in weeks, heart rate and others parameter. Statistical significance was defined as P value < 0.05.

Results
A total of seventy-one pregnant ladies with normal pregnancy were taken in this study.
Foetal ICT, IRT, ET and foetal pulse (FHR) were estimated in all foetuses. Mean ICT was 45.7 ± 7.0ms, mean IRT was 55.9 ± 6.7ms, and mean ET was 148.2 ± 10ms. The mean FHR was 142.26 ± 5.8 bpm and mean gestation age (weeks) is 33.16 ± 4.8. Mean MPI was 0.409 ± 0.052.
The coefficient correlation analysis reveals MPI is independent of both gestational age and FHR in [Table 1 and 2].

Table 1: Correlation between MPI and Gestational age (20–40 weeks)

Gestational age (weeks)	No. of Patient	MPI (mean ± SD)
Second trimester (20-27 weeks)	26	0.399±0.056
Third trimester (28-40 weeks)	45	0.415±0.050

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Table 2: Foetal echocardiographic parameters.

Foetal parameters	Time interval (mean±SD)
Foetal heart rate (bpm)	142.26 ± 5.84
Gestational age (weeks)	33.16 ± 4.81
Modified LV MPI	0.409 ± 0.052
ICT (ms)	45.7 ± 7.0
IRT (ms)	55.9 ± 6.7
ET (ms)	148.2 ± 10.8

Table 3: Relation between gestational age and MPI

No. of cases	71
Tie index	0.40 ± 0.052
Gestational age	33.16 ± 4.8
r value	0.017
P value	0.88

No correlation between MPI and Gestational age, so we say that MPI is independent to Gestational age in [Table 3].

Table 4: Relation between MPI and Heart rate

No. of cases	71
Tie Index	0.40 ± 0.052
FHR	142.26 ± 5.8
r value	0.030
P value	0.805

No correlation between MPI and foetal heart rate, so we say that MPI is independent to Foetal heart rate in [Table 4].

Discussion

Our knowledge of detecting early compromised foetal cardiac functions and monitoring its deterioration is still developing. In high-risk foetus, right appraisal of foetal myocardial function is of utmost importance. Early detection of subtle changes in myocardial function might be life-saving for the foetus and help in the timing of delivery. Raised MPI value exceptionally explicit bad perinatal results including stillbirth or neonatal death.[11-13] The myocardial performance index (MPI) is a tool estimating global cardiac function, which is reasonable and reproducible & can be used in routine ultrasound assessment.[14] It can pick up early myocardial dysfunction at the subclinical stage and could be helpful for the clinician to take the earliest suitable most measures to diminish perinatal sickness and mortality.

Tsutsumi et al. were the first to use the Tie index for the assessment of foetal global myocardial function. The LV MPI was significantly lower (0.43 ± 0.03) in the third trimester beyond 34 weeks of gestation as compared to the second-trimester foetuses between 18 and 26 weeks of gestation (0.62 ± 0.07).[15] The LV myocardial maturational changes significantly increased in the late gestation, and global ventricular function got affected by these maturational changes. This leads to the difference in MPI in the above-mentioned study. A similar decrease in MPI with advancing gestation was also noted by Chen et al.[16] In contrast to this, Friedman et al., Parasuraman et al and Russel and McAuliffe reported that the MPI values did not show any significant correlation with gestational age and heart rate.[17-20] Our study correlated well with the fact that the MPI does not correlate with either gestational age or heart rate. The technique for MPI measurement has been improved with

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time. Tsutsumi et al., in 1999, first reported the use of the MPI using two waveforms, and therefore, two cardiac cycles were used for measurements.[2] Then, further, Friedman et al. proposed a new position for the Doppler sample volume in 2003 and from which the LV MPI can be calculated from a single Doppler waveform.[3] Raboisson et al., in 2003, proposed that the Doppler click of the aortic valve opening be used as a landmark which helped to better estimate the time intervals of MPI calculation.[21] In 2005, Mod-MPI was introduced by Hernandez-Andrade et al. in which they used the beginning of opening and closing Doppler clicks of both the aortic and mitral valves as measurement landmarks for the different periods.[22] Using this method, there was a significant reduction in the inter- and intra-observer variability, and thus, the reproducibility of the index in foetal medicine was improved.

The clinical applications for MPI in early diagnosis and provision of professional assistance and guidance were examined. Foetal cardiovascular dysfunction was evaluated by MPI in different pathological conditions including intrauterine growth restriction,[23] maternal diabetes,[24-26] TTTS,[27] congenital heart malformations,[28] preeclampsia,[29] and foetal inflammatory reaction disorder in foetuses with preterm premature rupture of membranes and MPI values was raised in the above mentioned clinical conditions.[30] Raised MPI is profoundly sensitive and specific for the prediction of bad perinatal outcomes including stillbirth or neonatal death.[11-13]

Table 5: Comparative previous studies[4]

Study	Year	No. of patients	Modified MPI
Tsutsumi et al,[2]	1999	135	0.43± 0.03
Eidem et al,[15]	2001	125	0.36±0.06
Friedman et al,[3]	2003	74	0.53±0.13
Chen et al,[16]	2006	225	0.22±0.05
Hernandez-Andrade et al,[7]	2007	557	0.37±0.029
Ghawi et al,[17]	2013	420	0.464±0.08
Nair and Radhakrishnan,[18]	2016	200	0.42±0.03
Tayade et al,[4]	2017	60	0.35±0.03
Present study	2019-20	71	0.40±0.052

It is as of now a well-known fact that machine settings and methods utilized for MPI assessment altogether influence the reproducibility, and it might represent the reason for the wide variation of the normal range. The precise work of MPI values in complicated pregnancies is constrained because of the absence of a universally acceptable normal reference range. To set up a universally acceptable normal reference range of MPI, huge multicentre studies are required to take data of the MPI utilizing normalized machine settings and methods.

Limitations

1. There should be a universally accepted uniform normal range of MPI values.
2. Foetal movement affects the four-chamber apical heart view.
3. Maternal adiposity and anterior placenta may affect image acquisition and quality.
4. Calliper Placement in Phase of Valve Clicks.
5. Standard Technique and Machine Setting.

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Conclusion

Our study gives the normal range of MPI in the normal heart foetuses of the Indian population and it also shows that MPI is independent of gestational age and FHR. Thus, MPI ought to be utilized for the underlying initial assessment of the foetal heart and babies with congenital heart defect just as for the follow up of foetuses with a heart defect. MPI is additionally conceivably helpful for evaluation the foetal cardiac status in noncardiac disease state. It detects subclinical foetal cardiovascular malfunction and feasible and reproducible also, so can be used for intrauterine foetal cardiovascular monitoring for foetal wellbeing.

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