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RESEARCH ARTICLE

Association Between Hydronephrosis Severity and Renal Function in Patients with Ureteric Obstruction

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Abstract: ***Background***: Nephrolithiasis is a common urological condition that predominantly affects adults during their most productive years and may lead to recurrent episodes of renal colic, reduced quality of life, and an increased risk of chronic kidney disease. The purpose of the study is to evaluate the relationship between hydronephrosis severity and renal function parameters in patients with ureteric obstruction. ***Aim of the study:*** The aim of the study was to evaluate the relationship between hydronephrosis severity and renal function parameters in patients with ureteric obstruction. ***Methods:*** This cross-sectional study at the Department of Urology, Bangladesh Medical University (BMU), Dhaka, Bangladesh, from January to December 2024, included 80 adult patients with ureteric obstruction. Hydronephrosis severity was assessed by ultrasonography, renal function by serum creatinine, eGFR, and split renal function, and symptom duration recorded. Data were analyzed using SPSS version 26 with one-way ANOVA and Pearson's correlation ($p < 0.05$). ***Results:*** Among 80 patients (mean age 48.2 years, 65% male), ureteric calculi caused 72.5% of obstructions. Hydronephrosis was mild in 32.5%, moderate in 35%, and severe in 32.5%. Renal function declined with severity—creatinine 1.0→2.3 mg/dL, eGFR 85.1→36.8 mL/min/1.73 m² ($p<0.001$). Hydronephrosis grade correlated with creatinine ($r=0.79$) and inversely with eGFR ($r=-0.82$). Longer symptom duration (>48 h) was linked to greater severity and lower eGFR. ***Conclusion:*** Increasing hydronephrosis severity and longer symptom duration were strongly associated with progressive renal function decline, emphasizing the need for early detection and prompt management of ureteric obstruction.

Keywords: Fetal cardiac function, Myocardial Performance Index (MPI), High-risk pregnancy, fetal echocardiography.

INTRODUCTION

Normal cardiac function implies preserved systolic and diastolic performance and synchronized cardiac time periods. Primary cardiovascular and systemic disorders may influence the fetal heart **(1)**.

Assessment of fetal cardiac function is increasing identified as important step in evaluation of the fetus, particularly in the presence of high risk pregnancy such as, fetal growth restriction, preeclampsia and maternal diabetes or through different pathophysiological states that include hypoxia, increased fetal cardiac afterload **(2)**.

Fetal cardiac function evaluation reflects placental vascular function from fetal side, if utero-placental insufficiency is present, cardiac function changes occurs before Doppler changes in fetal peripheral vessels **(3).**

The myocardial performance index (MPI) or Tei index is non-invasive Doppler derived method to assess global cardiac systolic &diastolic function **(3)**.

MPI is calculated by the sum of isovolumteric contraction time (ICT) which is the interval between the atrioventricular valves closing and the semilunar valves opening and isovolumetric relaxation time (IRT) which is interval between the semilunar valves closing and the atrioventricular valves opening then divided by ejection time (ET) which is the time between the semilunar valve opening and closure , It can also be defined as (a–b)/b, where 'a' is the interval between the end and the onset of systemic ventricular inflow, and 'b' is the ejection time of the systemic outflow **(1).**

MPI is a potential useful predictor of global cardiac function, which is not influenced by heart size, shape, orientation, geometry or rate**(4,5).** Its application in fetus has advantages over the application in adults since it is possible to measure the atrioventricular and semilunar valves flows simultaneously, removing the inaccuracy predisposed in measuring different heart beats **(6)**.

This study aimed: to evaluate fetal cardiac function by fetal echocardiography using MPI in high risk pregnancy and compared to healthy group to identify its utility in prediction of perinatal outcome.

Patients and methods :
Study Design and Setting:

This case control comparative study was conducted on sample of 100 pregnant ladies were referred from Obstetrics and Gynecology Department to Diagnostic Radiology Department Tanta University Hospitals over duration of two years,this study was approved from Tanta University Hospitals' Ethical Committee (approval code 36264MD110/6/23).

The sample was divided into two groups:

- **Control group:** 50 pregnant ladies with no-risk pregnancies.
- **High-risk group:** 50 pregnant ladies with high-risk pregnancies.

Inclusion Criteria

- Gestational age (GA) between 20 to 34 weeks of gestation.
- No-risk pregnancies referred for routine second-trimester anomaly scan ultrasound.
- High-risk pregnancies including:
  - Diabetes mellitus (DM)
  - Hypertension (HTN)
  - Intrauterine growth restriction (IUGR)

Exclusion Criteria

- Pregnant females in the first trimester.
- Fetuses with structural abnormalities either cardiac or extra-cardiac anomalies, multiple pregnancy, hydropic fetus, chromosomal abnormalities or intra-uterine infection.

Methods

- Every pregnant lady was subjected to through medical history (age, chronic illness, gestational DM, HTN,) menstrual history including (1st day of last menstrual period (LMP) and regularity of the cycle) and obstetric history (gravity, parity and assisted reproductive technology)
- Ultrasonographic examination was performed using ultrasound equipment (SAMSUNG Hb 60 machine) skilled of high resolution gray scale, color and pulsed wave Doppler modes prepared with a 3-5MHz probe transducer.
- The examination was done either in supine or lateral position and measurement were recorded in absence of fetal movement, fetal respiration or uterine contraction.
- **Detailed obstetric ultrasound** was done to obtain fetal biometry and calculating the estimated fetal weight (EFW) by hadlok 4 formula and correlate it to its percentile according to GA, then assessment of placenta and amniotic fluid index (AFI).
- **-Detailed anatomy scan** was performed according to International Society of Ultrasound in Obstetrics and Gynecology (ISOUG)guidelines to exclude fetuses with congenital anomalies **(7).**
- **-Fetal echocardiography** was performed according to ISOUG guidelines to assess situs ,four chamber view, right, left outflow tracts, three vessels and three vessels trachea views **(8).**
- -Cardiac function were measured by spectral Doppler U/S with the following setting sample volume (2-3mm) , Doppler sweep: 420Hz, wall motion filter : 200-400 Hz , angle of insonation <15 degree.
- -Left MPI was detrmined by land marks of click of both mitral and aortic valves as described by Hernandz-Andrade **(9)** in apical four or five chamber view and placing the sample volume on lateral wall of ascending aorta including the aortic valve (AV) and mitral valve (MV), so simultaneously we could record the measurement of both valves.

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- The **ICT** was obtained from the closure of mitral valve (MV) to opening of aortic valve (AV) , **IRT** from the closure of AV to opening of MV and the **ET** between the opening and closure of AV, the **MPI** of left ventricle was calculated by the sum of (ICT+IRT) divided by ET, as shown in **figure(1)**

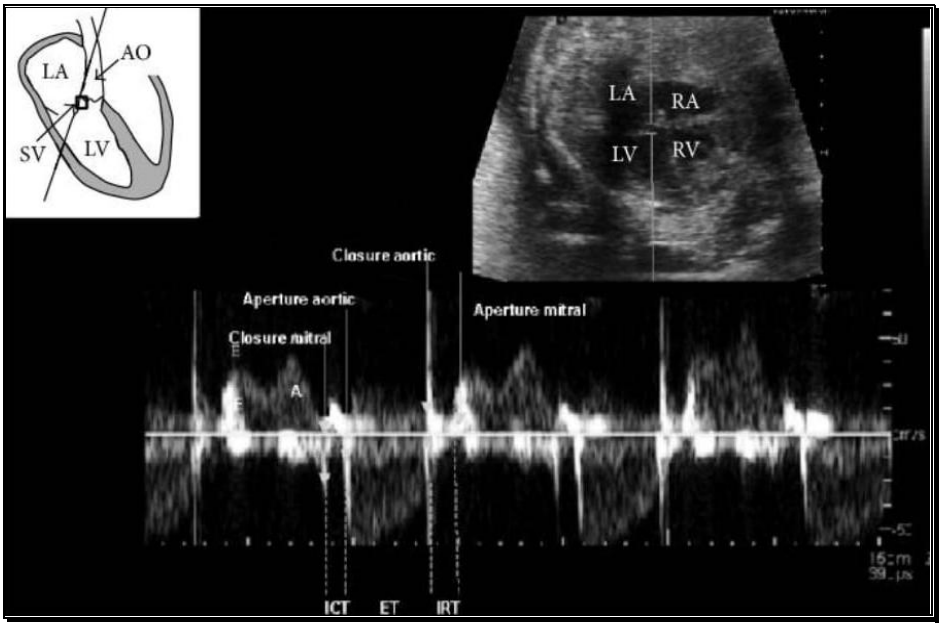


Fig. (1): Doppler assessment of the left myocardial performance index. The sample volume is located over the lateral wall of the aorta, close to the mitral valve. References for the time-period estimations are based on the echoes from the mitral and aortic valve movements. The E/A waveform is always displayed as positive flow. ET, ejection time; ICT, isovolumetric contraction time; IRT, isovolumetric relaxation time **(9).**

- **The right MPI** was measured by obtaining the waveform images of right ventricle (RV) inflow & outflow, in the apical four chamber view the RV inflow images was recorded by placing the sample gate at tricuspid valve (TV) leaflet .
- In the RVoutflow tract view, the RV outflow images were recorded by placing the sample gate at pulmonary valve (PV) leaflet.
- The **(a)** time interval was measured from closure to the aperture of TV, and the (**b)** time interval or **ET** was measured from the aperture to the closure of PV,so the **MPI of RV** was calculated by the following equation (a-b)/b as shown in **figure (2).**

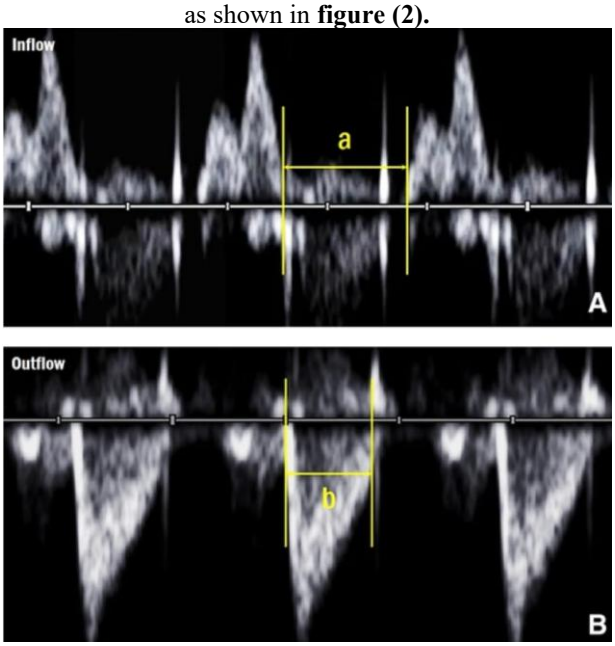


Fig. (2) Measurement of the right myocardial performance index using the the following method. The "a" time interval is from the closure to the opening click of the tricuspid valve **(A),** and the "b" time interval is from the opening to the closure click of the pulmonary valve **(B) (10).**

- The above mentioned measurements were recorded from control and study groups then analyzed and compared.

Post natal information about birth weight, Apgar score ,need for neonatal intensive care unit (NICU) admission, duration of admission, neonatal resuscitationand peri-natal mortality were recorded.

Ethical Considerations

- Informed consent obtained from all participants, Complete explanation of the study's nature and purpose provided, Patient privacy and confidentiality were ensured using coded files, Any unexpected risks were reported to participants and the ethical committee.

Statistical Analysis

- **Software:** IBM SPSS version 20.0, **Qualitative data:** Number and percentage, **Quantitative data:** Range, mean, standard deviation, median, **Significance level:** $p < 0.05$, **Statistical Tests Used:Chi-square test:** Comparison of categorical variables, **Fisher's exact test:** Correction for chi-square if >20% of cells had expected count <5, **Student t-test:**Examining two sets of quantitative data that are typically distributed, **Kappa (κ) test:** Agreement analysis<0.20: Poor0.21–0.40: Fair0.41–0.60: Moderate0.61–0.80: Good0.81–1.00: Very good

Cases:

Case 1

A 36-year-old multi-para pregnant lady was examined at 30 weeks and 0 days of gestation, with pre-eclampsia.

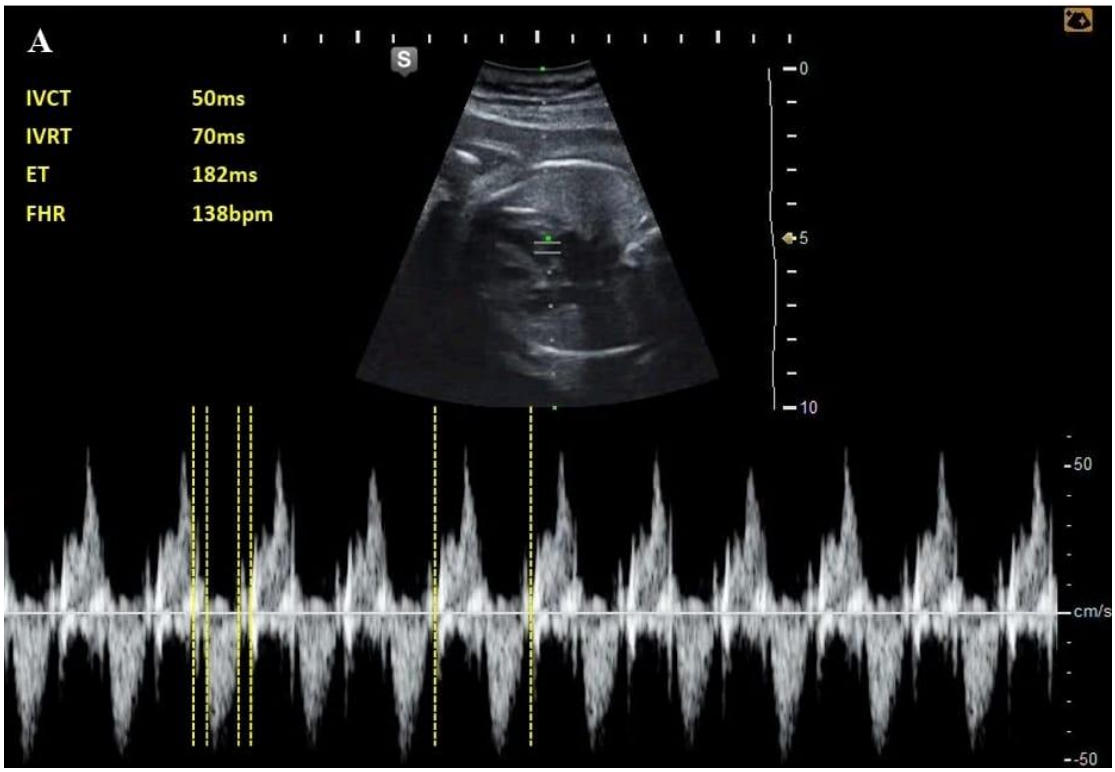
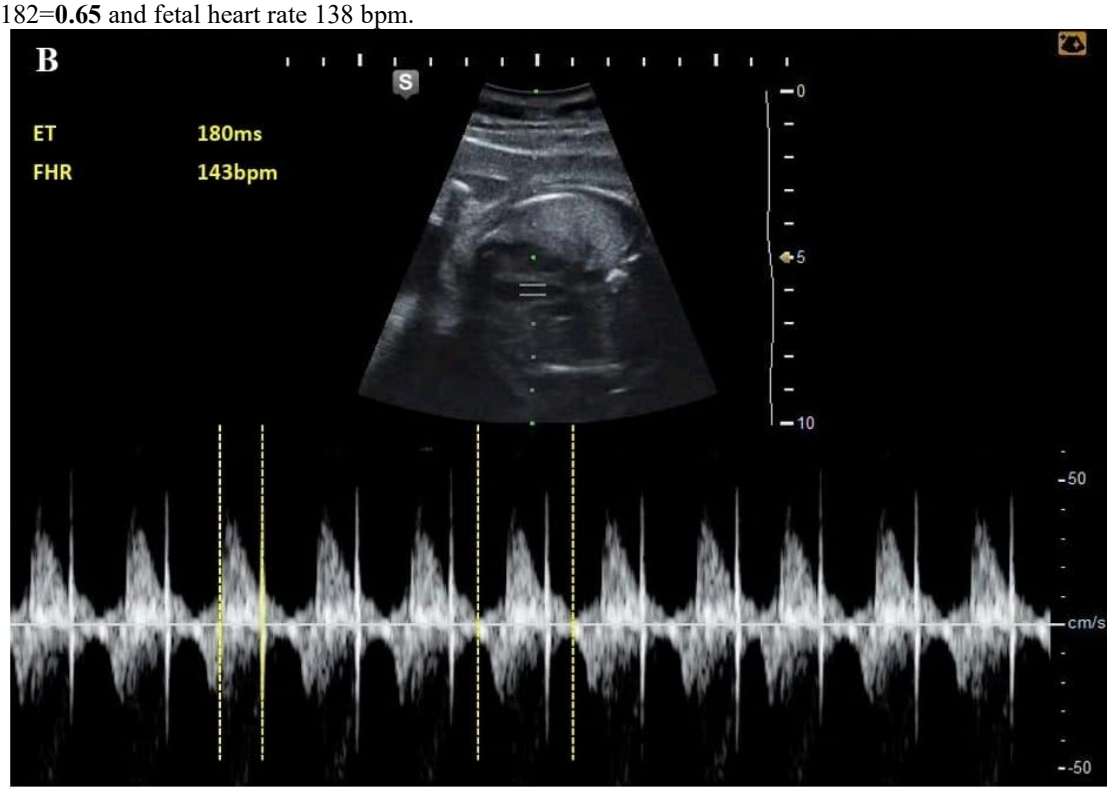


Fig. (3A) showing Ultrasound Doppler trace of isovolumetric contraction time (50ms), ejection time (182ms), isovolumetric relaxation time (70ms) for assessment of left ventricular **MPI** (IVCT+IVRT)/ET with **highTei index** (50+70)/182=**0.65** and fetal heart rate 138 bpm.



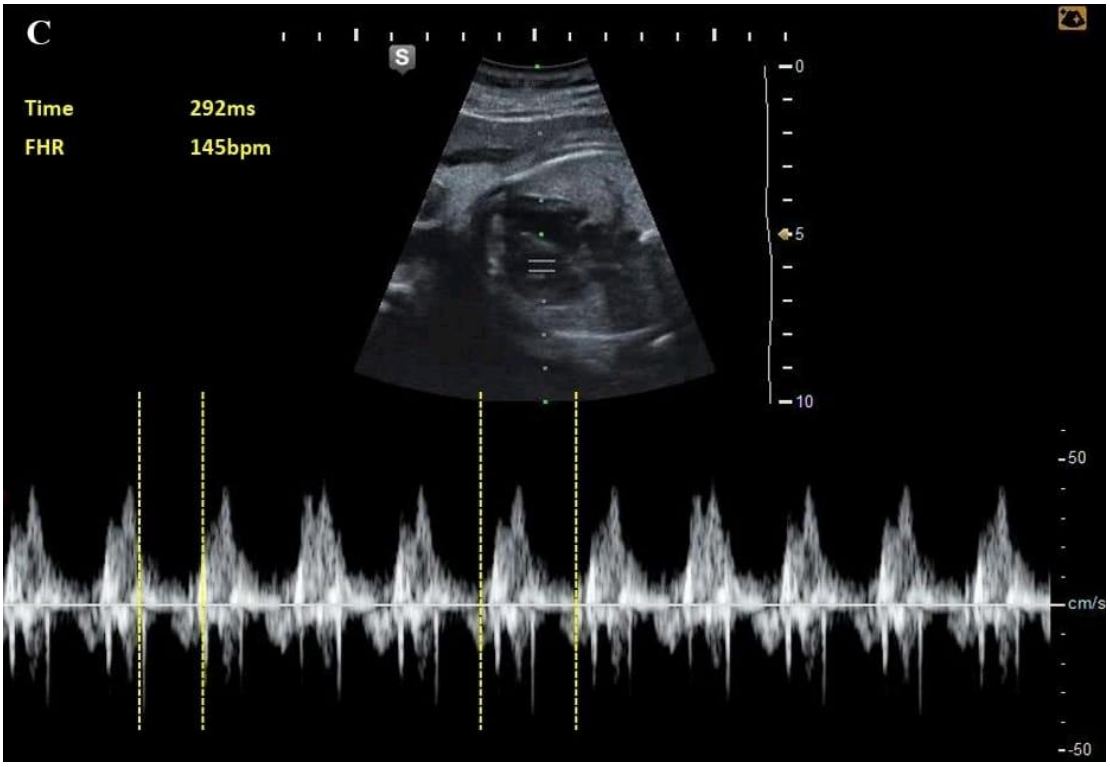


Fig. (3B and C) Measurement of right ventricular **(MPI)** using pulsed wave Doppler just below the PV**(b)**time interval between the aperture and the closure of the pulmonary valve was measured in **(B)** and at the tip of TV leaflets **(a)** time interval from closure to aperture click of the tricuspid valve was measured in **(C)** and then MPI was calculated with following way (a-b)/b, so Tei index of RV (292-180)/180=**0.62** with fetal heart rate 143-145 bpm.

Case 2:

A 29-year-old primi-gravida pregnant lady, was examined at 28 weeks and 5 days of gestation by LMP, however the GA by scan was 24 weeks and 4 days and diagnosed with IUGR.

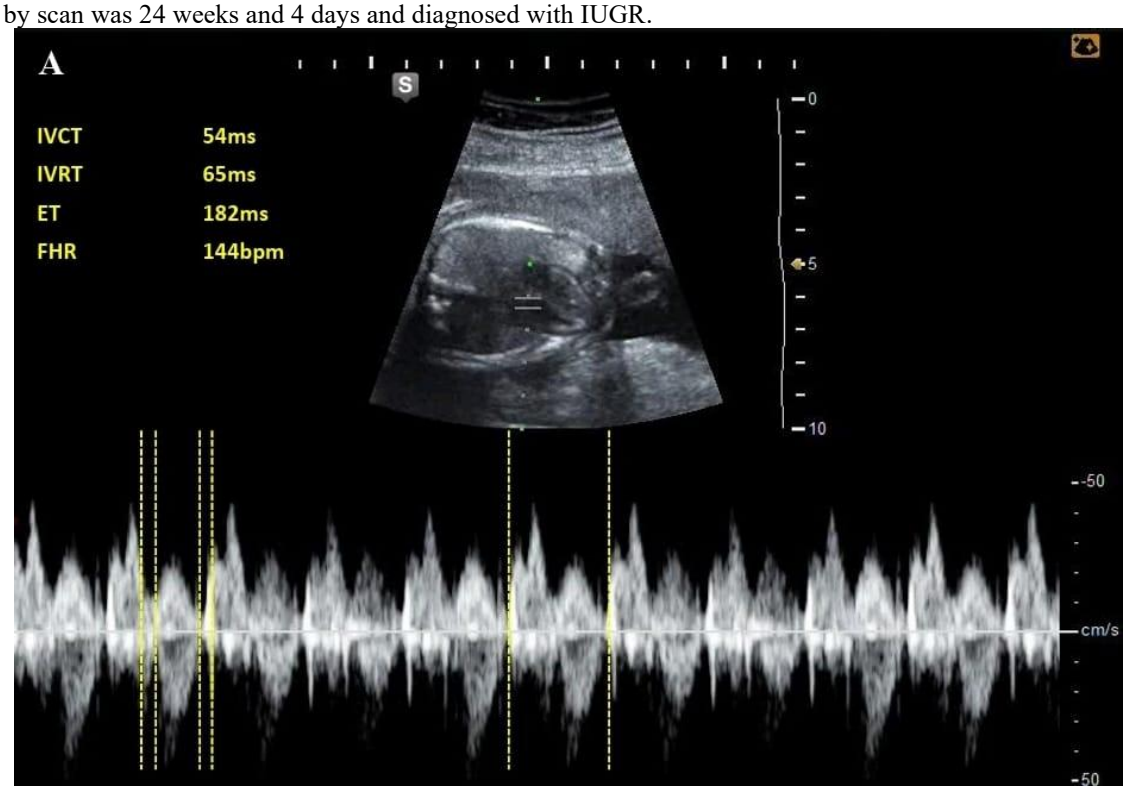


Fig. (4A) showing Ultrasound Doppler trace of isovolumetric contraction time (54ms), ejection time (182ms), isovolumetric relaxation time (65ms) for assessment of left ventricular MPI (IVCT+IVRT)/ET with **highTei index** (54+65)/182=**0.65** and fetal heart rate 144 bpm.

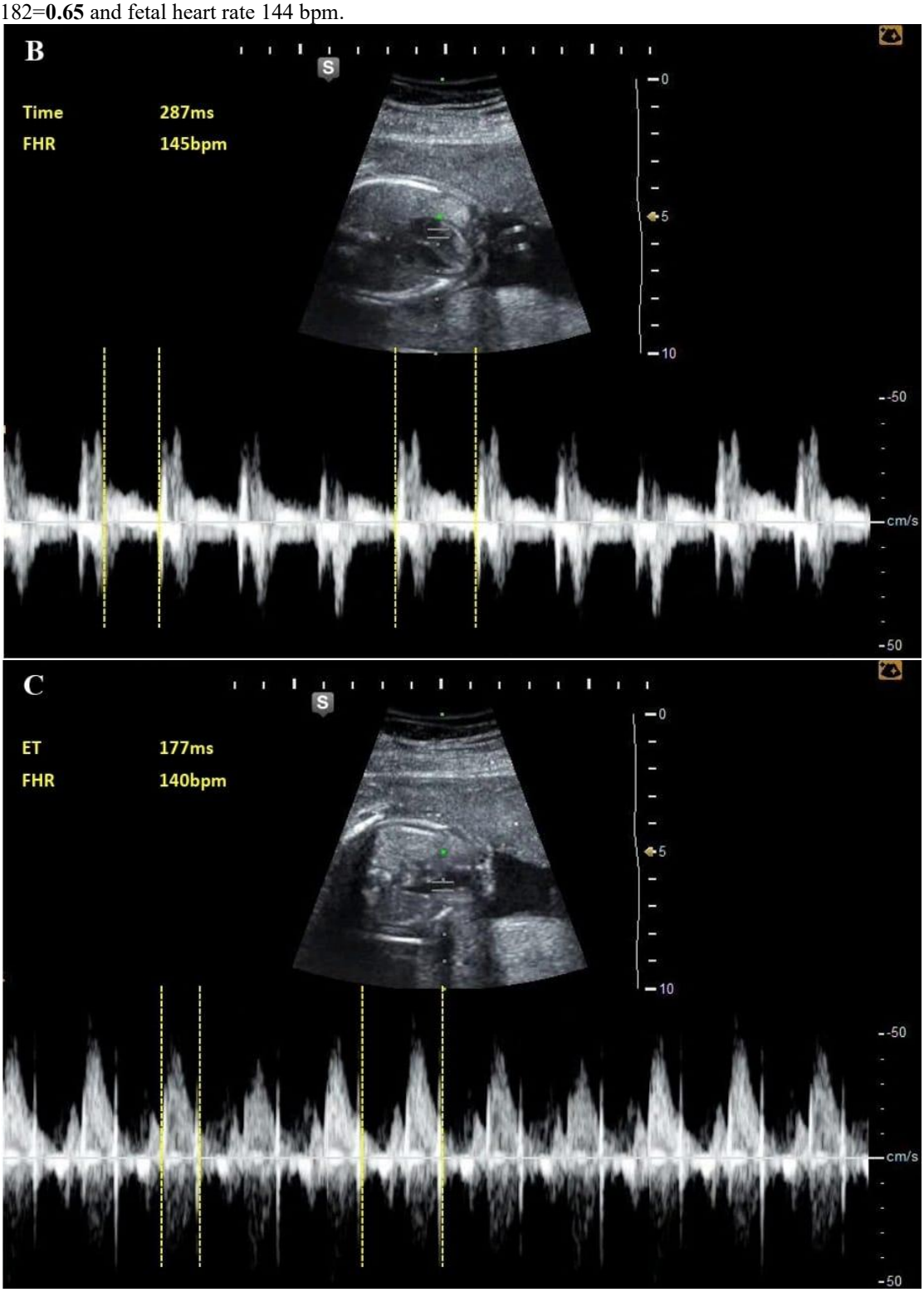


Fig .(4B and C) Measurement of right ventricular **(MPI)** using pulsed wave Doppler at the tip of tricuspid leaflets and measure **(a)** time interval from closure to aperture click of the tricuspid valve as shown in **(B)** and just belowthe PV**(b)**time interval between the aperture and the closure of the pulmonary valve was measured in **(C)**thenMPI was calculated with following way (a-b)/b, so **high Tei index of RV** (287-177)/177=**0.62**with fetal heart rate 140-145 bpm.

Case 3

A 34-year-old multi-para pregnant lady with gestational diabetes was examined at 26 weeks and 5 days of gestation.

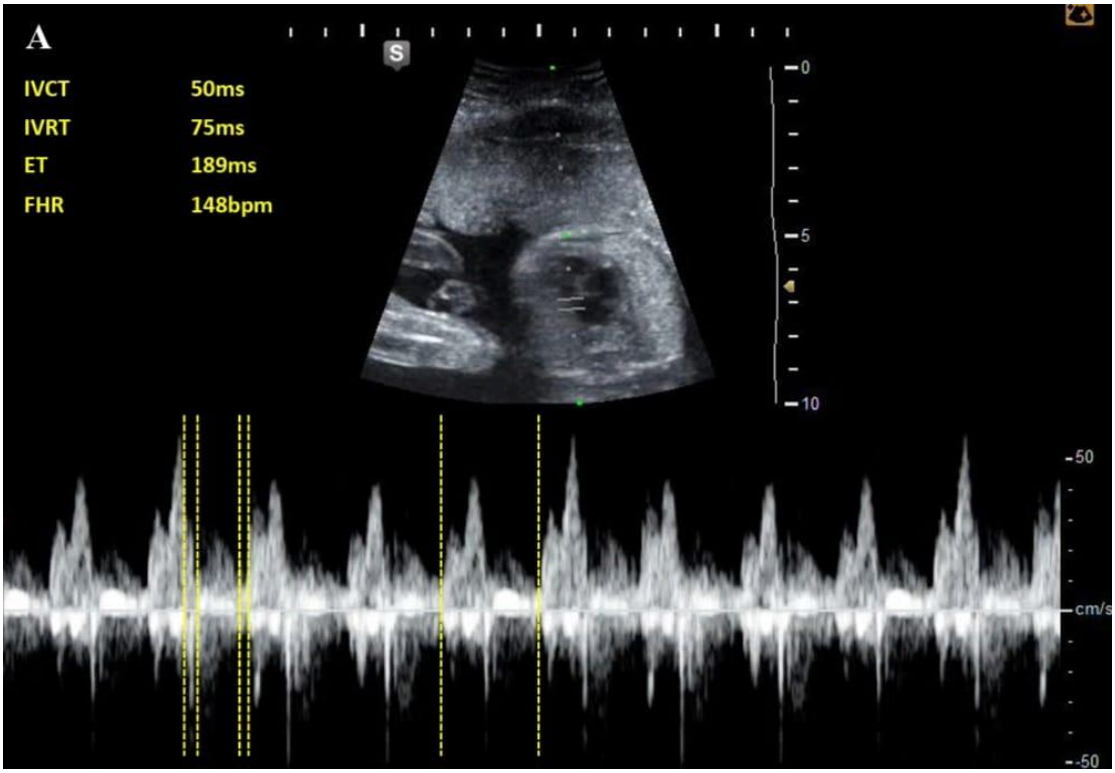
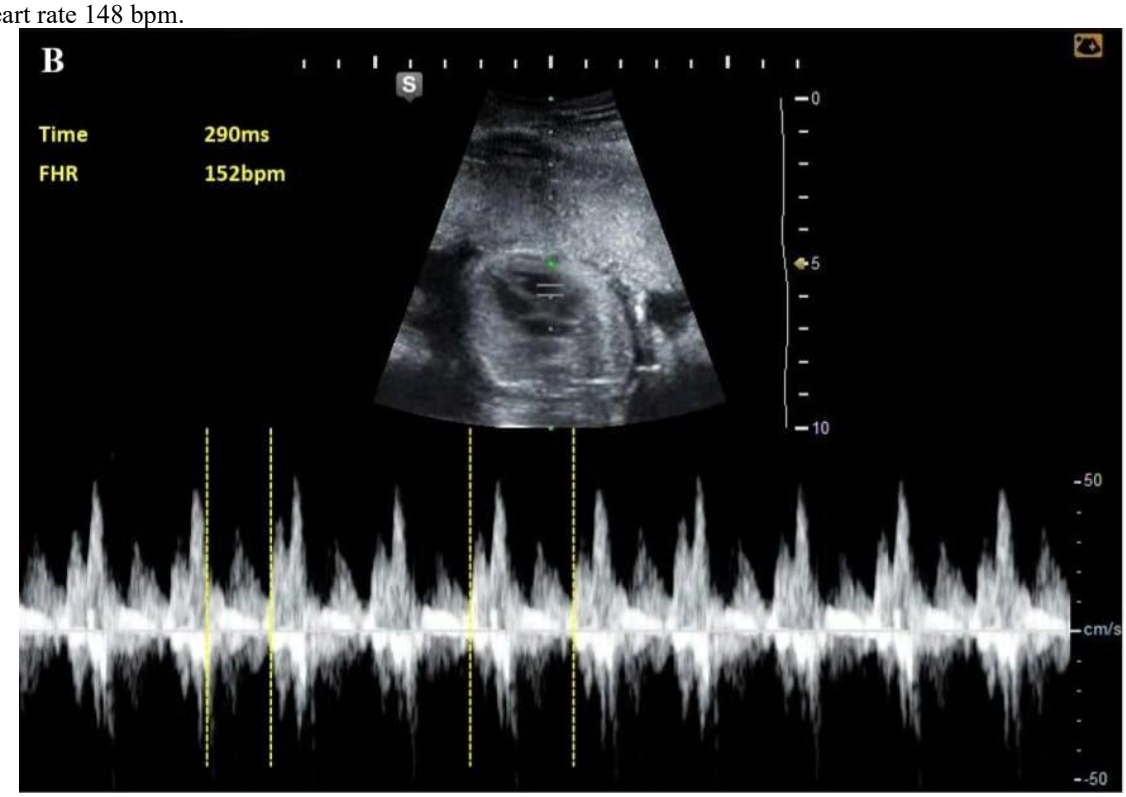


Fig . (5A) showing Ultrasound Doppler trace of isovolumetric contraction time(50ms), ejection time(189ms), isovolumetric relaxation time(75ms) for assessment of left ventricular MPI (IVCT+IVRT)/ET with **high Tei index**(50+75)/189=**0.66** and fetal heart rate 148 bpm.



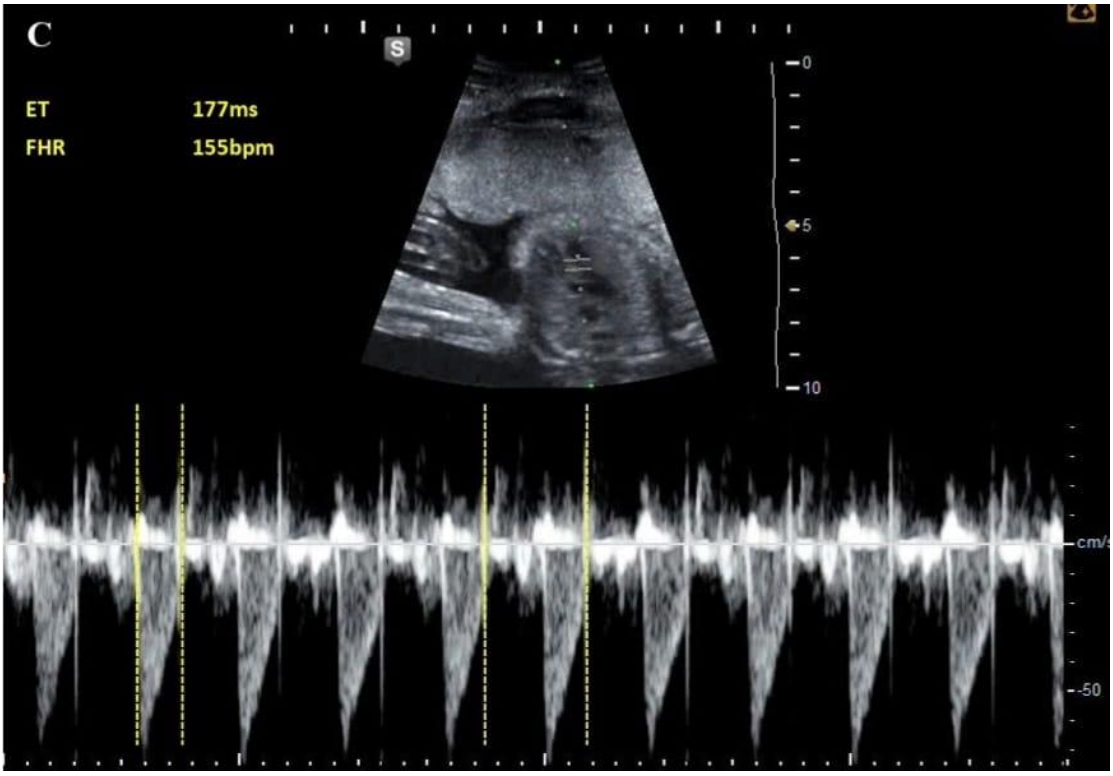


Fig. (5B&C) Measurement of right ventricular **(MPI)** using pulsed wave Doppler at the tip of tricuspid leaflets and measure **(a)** time interval fromclosure to aperture click of the tricuspid valve as shown in **(B)** and just below the PV**(b)**time interval between the aperture and the closure of the pulmonary valve was measured in **(C)**then MPI was calculated with following way (a-b)/b,with **high Tei index** of right MPI (290-177)/177=**0.63** with fetal heart rate 152-155 bpm.

RESULTS

There was insignificant relation between mother age and presence of risk factor (p-value 0.185) and also the relation was insignificant between fetal heart rate and risk factor (p-value 0.690), as well as gestational age (p-value 0.557).
Table **(1)** demonstrated Left ventricle Tei index ranged at control group between 0.29-0.62 with mean about 0.47 ± 0.09 and become higher at high-risk group ranged from 0.55-0.70 with mean about 0.65 ± 0.04.

Table 1: Comparison between both groups regarding left MPI index.

	Group 1 (Normal pregnancy) (n=50)	Group 2 (High risk pregnancy) (n=50)	T	p
Left Tei index			12.686	<0.001*
Mean ± SD	0.47 ± 0.09	0.65 ± 0.04		
Min. – Max.	0.29 – 0.62	0.55 – 0.70		

Table (2) shows that left MPI parameters (ET, IRT and ICT) at both control and high-risk groups showed increased ET at high-risk group ranging between 155-189 with mean about 176.3 ± 9.8), also IRT showed increasing in its value in high-risk group about 30-75 with mean about 62.9 ± 8.12. ICT as well has been increased at high-risk group 20-65 with mean 51.9 ± 8.63.

Table 2: Comparison between both groups regarding left MPI parameters

	Group 1 (Normal pregnancy) (n=50)	Group 2 (High risk pregnancy) (n=50)	T	p
ET			7.004	<0.001*
Mean ± SD	163.3 ± 8.79	176.3 ± 9.80		
Min. – Max.	145.0 – 180.0	155.0 – 189.0		
IRT			9.775	<0.001*
Mean ± SD	46.1 ± 8.63	62.9 ± 8.12		
Min. – Max.	30.0 – 60.0	30.0 – 75.0		
ICT			13.033	<0.001*
Mean ± SD	31.4 ± 6.97	51.9 ± 8.63		
Min. – Max.	20.0 – 45.0	20.0 – 65.0		

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Table (3) and Figure (6) showed Significant accuracy of left MPI parameters with P value of ET <0.001 and accuracy about 82.0% , P value of IRT <0.001 with accuracy about 87% and ICT accuracy about 89.0% and P value <0.001.

Table (3): Left MPI parameters accuracy in diagnosis of high-risk pregnancy.

	AUC	p	Cutoff	Sensitivity	Specificity	PPV	NPV	Accuracy
ET	0.845	<0.001*	>171.5	80.0%	84.0%	83.3%	80.8%	82.0%
IRT	0.922	<0.001*	>59.0	80.0%	94.0%	93.0%	82.5%	87.0%
ICT	0.946	<0.001*	>43.5	80.0%	98.0%	97.6%	83.1%	89.0%

PPV: Positive Predictive Value
NPV: Negative Predictive Value
AUC: Area Under the Curve
***p ≤ 0.05 (Statistically significant)**

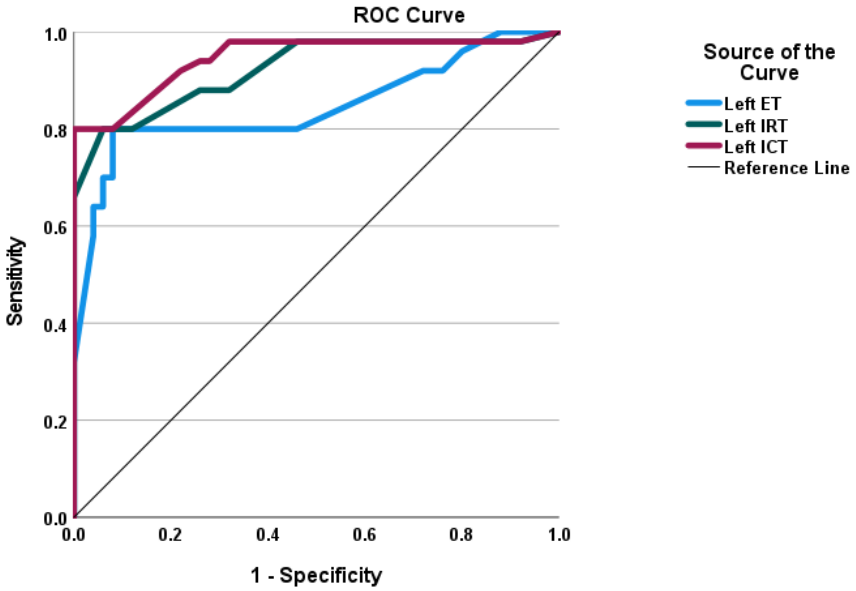

Fig .(6): ROC curve of left Tei index parameters accuracy in diagnosis of high-risk pregnancy

Right MPI showed high values in high risk group ranged between (0.55-0.69) with mean about 0.62± 0.04compared to 0.35-0.61 with mean about 0.49± 0.08 in control group ,itsparameter (ET)also showed increased duration at high-risk group being about 155-196 with mean about 175.8 ± 9.67, in comparison to control group with P value <0.001.

Table 4 and Figure 7 illustrated that Right and left Tei index both showed significant accuracy in diagnosis of high-risk pregnancy with P value at left MPI <0.001 with accuracy about 91.0%.Right MPI showed P value about <0.001 with accuracy about 89.0%

Table (4): Right & left Tei index accuracy in diagnosis of high-risk pregnancy.

	AUC	p	Cutoff	Sensitivity	Specificity	PPV	NPV	Accuracy
Left Teiindex	0.979	<0.001*	>0.57	98.0%	84.0%	86.0%	97.7%	91.0%
Right Tei index	0.971	<0.001*	>0.585	94.0%	84.0%	85.5%	93.3%	89.0%

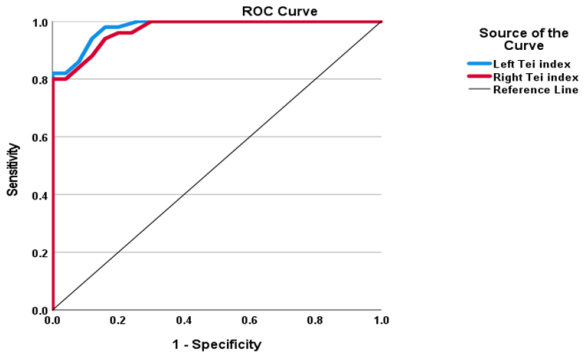

Fig. (7): ROC curve of right & left Tei index accuracy in diagnosis of high-risk pregnancy.

The post-natal follow up of high-risk groups revealed that among 17 fetuses in diabetic high-risk group about 9 (52.9%) had adverse perinatal outcome and need for neonatal resuscitation and at HTN group about 10/17 (58.8%) fetuses need neonatal resuscitation.As well as at IUGR group about 9/16 (56.2 %) fetuses had adverse perinatal outcome and need for neonatal resuscitation.

DISCUSSION

The myocardial performance index importance in fetal cardiac function assessment is increased as it is accessible, non-invasive Doppler derived method, able to be integrated into the standard US assessment of the fetus to improve the accuracy of predicting the adverse perinatal outcome in high risk pregnancy leading to more comprehensive decisions of the appropriate time of delivery, it is also possible to identify early state of cardiac function impairment before alteration in arterial &venous Doppler indices (11).

High MPI values are related to ventricular dysfunction which could be a valid predictor of fetal heart condition inearly cardiac response to different intra-uterine stressors (12).

We aimed at our study to evaluate fetal cardiac function by fetal echocardiography usin g MPI in high risk pregnancy & compared to healthy group, enabling early diagnosis and management, as well as assisting in a smooth transition between pre- and postnatal care by providing appropriate medical attention immediately after birth. During our study, we assessed left and right MPI and measured the time components of myocardial performance in both ventricles.

The range of gestational age in control fetuses was 23–34 weeks (mean 27.6 ± 3.16) and 24–34 weeks in high-risk pregnancies. This aligns with Pasierb et al.,(13) who reported a mean gestational age at initial prenatal cardiology consultation of 26.5 weeks, as well as Carvalho et al., (8)who reported mean gestational ages of 26.2 ± 5.2 and 25 weeks, respectively.

Perriyanayaki et al., (14) performed fetal echocardiography in 500 antenatal cases, reporting that the majority of cardiac abnormalities were seen between 28–32 weeks, while Takita et al.,(15) reported a gestational age of 26–28 weeks at diagnosis.

Fetal heart rate ranged from 123 to 150 bpm in controls (mean 139.3 ± 5.79) and 129–155 bpm in high-risk pregnancies (mean 139.8 ± 6.26), with no significant relation to risk factors ($p = 0.690$), consistent with Oliveira et al., (1) who reported that MPI did not vary with fetal heart rate except in the presence or absence of accelerations.

Right MPI in our controls ranged 0.35–0.61 (mean 0.49 ± 0.08), similar to Scharf et al., (16) with slightly greater values in the third trimester but without statistical significance.

Maheshwari et al ., (17) proved that right MPI is a crucial metric due to the developing baby's heart is mostly located on the right side of the body. Because alterations to the right heart's function occur before those to the left heart in the setting of cardiac pathology, right MPI may also provide early symptoms of disease.

High-risk maternal conditions affected fetal cardiac morphology and function. In diabetic pregnancies, both left and right MPI were significantly higher than controls (0.55–0.70, mean 0.66 ± 0.03; 0.60–0.69, mean 0.66 ± 0.03). IRT was prolonged (left 63.8 ± 11.39; right 61.7 ± 7.72), ICT increased (50.8 ± 10.15), and ejection time (ET) increased (178.4 ± 9.49), indicating impaired systolic and diastolic function. Adverse outcomes occurred in 52.9% of cases, consistent with Karkia et al.,(18).

Among our IUGR cases, left MPI (0.65 ± 0.04) and right MPI (0.64 ± 0.05) were higher than in healthy fetuses. IRT (62.4 ± 6.61),ICT (52.1 ± 8.24, $P = 0.001$)and ET (174.4 ± 10.24) were all prolonged, reflecting ventricular dysfunction .

This result is in agreement with the findings of Şimşek and Köse, (19) who found that MPI is a potentially effective technique in evaluating fetuses with suspected IUGR, which is vital in distinguishing critical and non-critical IUGR cases and predicting neonatal prognosis and our results also are consistent with those of Ali et al., (20) who found a link between fetal cardiac function degradation and the progression of fetal compromise in IUGR, and also Alici Davutoglu et al., (21) who found MPI to be beneficial in predicting poor perinatal outcome in IUGR

Adverse outcomes occurred in 56.2% of our IUGR cases. Prolonged IRT indicates early myocardial dysfunction due to delayed cardiomyocyte relaxation. This was in line with study of Wang et al., (22) who showed increased MPI in IUGR group associated with adverse outcome. The sensitivity and specificity of MPI predicting adverse outcome were 60% with cutoff value was 0.47.

In our preeclampsia and hypertension cases, MPI was elevated (left 0.65 ± 0.04, right 0.66 ± 0.03), with prolonged IRT (62.6 ± 5.48), ICT (52.8 ± 7.69), and ET (177.8 ± 9.85), suggesting increased fetal cardiac afterload and early subclinical systolic and diastolic changes. Similar results were reported by Cheng Chen et al., (23) who discovered a significant disparity in the MPIs between the control group and the group with pregnancy-induced hypertension syndrome. As well as Omeroglu et al., (24) showed that the MPI increased in conditions where cardiac afterload increased secondary to placental vascular resistance in pre-eclamptic mothers.

Adverse outcomes in preeclampsia and hypertensive group occurred in 58.8% of our cases, this in line with Tadese et al., (25) who reported frequent low

birth weight, preterm delivery, NICU admission, and low APGAR scores in similar group.

Conclusion:

The MPI is considered a reliable and useful tool in the study of fetal heart function in several conditions such as: intrauterine growth restriction, pre-eclampsia, and maternal diabetes, MPI elevations have been evidenced in different pathologic states that affect the fetal systolic and diastolic cardiac functions. These results reinforce its clinical relevance once a demarcation of reference values of normality is achieved. It is quite important to diagnose these pathologies and conduct real-time evaluations of high-risk pregnancies during the maturation and development of the fetus.

Abbreviations:

MPI	Myocardial performance index
ICT	isovolumetric contraction time
IRT	isovolumetric relaxation time
ET	Ejection time
IUGR	Intra-uterine fetal growth restriction
DM	Diabetes mellitus
AFI	Amniotic fluid index
EFW	Estimated fetal weight
GA	Gestational age
HTN	Hypertension
ISOUG	International Society of Ultrasound in Obstetrics and Gynecology
US	Ultrasound
AV	Aortic valve
MV	Mitral valve
TV	Tricuspid valve
PV	Pulmonary valve
RV	Right ventricle
LMP	1st day of Last menstrual period
NICU	Neonatal intensive care unit
ROC	Receiver operating characteristic curve

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