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PULMONARY VEIN PULSATILITY INDEX AS AN EMERGING DOPPLER PARAMETEER TO ASSESS FETAL CARDIAC DYSFUNCTION

Obstetrics & Gynaecology

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ABSTRACT

Introduction: In placental insufficiency modification of left heart compliance occurs with resultant increase in placental vascular resistance .Pulmonary vein flow pattern reflect altered left atrial pressure and could be used as a parameter for cardiac dysfunction assessment in Intra Uterine Growth Restricted Fetus.(IUGR) **Aim:** To compare Pulmonary Vein Pulsatility Index (PVPI) between intrauterine growth restricted foetuses and appropriate for gestational age(AGA) **Material and Methods:** A prospective study was conducted in SMS medical college, Jaipur , involving 80 singleton foetuses ≥ 28 weeks of gestation divided into two groups 40 IUGR and 40 AGA . Pulmonary vein pulsatility index was obtained by fetal echocardiography. **Results:** The mean PVPI in the IUGR foetuses and AGA foetuses was statistically significant and that was 1.23 + 0.21 and 0.78 + 0.13 respectively {p- value 0.001}.These findings suggests that IUGR induces primary cardiac changes which could explain the increased predisposition to cardiovascular disease in adult life. **Conclusions:** Increased PVPI in IUGR reflects reduced left ventricle compliance and altered left atrial dynamics. As left ventricle dysfunction occur prior to right ventricle our result suggests that PVPI could be an early echocardiography parameter of fetal diastolic function in IUGR and this fetal echocardiography parameter (PVPI) identifies a high risk group within the IUGR foetuses which could be targeted for early screening of blood pressure and other cardiovascular risk factor as well as promoting healthy life style in future.

KEYWORDS

Fetal echocardiography, uteroplacental insufficiency,intrauterine growth restriction, pulmonary vein pulsatility index

INTRODUCTION

Prediction of perinatal mortality is censorious for the clinical management of preterm intra uterine growth restricted fetus.[1] Many approaches have been suggested to monitor these fetuses including arterial and venous Doppler, CTG and BPP, but to date, no standard management for these cases has been accepted. Longitudinal studies manifested that ductus venosus (DV) flow worsen earlier than does BPP and could be a more sensitive indicator for the prediction of perinatal mortality in intrauterine growth restricted foetuses[2]. In Intrauterine growth restricted foetuses, raised uteroplacental vascular impedance leads to favoured flow to left ventricles, with consequent alteration of its compliance and raised left atrial (LA) pressure[3]. Raised pulsatility index (PI) of the uterine and umbilical arteries are considered to be major Doppler ultrasound signs of placental dysfunction and the evaluation fetal–placental hemodynamics by doppler ultrasound has been widely used[2]. Changes in fetal hemodynamics take place in order to save vital organs from hypoxia. The heart always plays a key role in fetal adaptive mechanism that underlies placental inadequacy, which encompasses a sequence of progressive changes in order to facilitate vascular and metabolic adaptation.

In Intra uterine growth restriction , since the subclinical cardiac disorder is present from early stages of fetal worsening , the evaluation of fetal diastolic dysfunction is an important parameter that might aid to ameliorate perinatal outcome. [4]

In recent years new cardiovascular parameter have been suggested for foetal evaluation.

The raised uteroplacental vascular resistance and right ventricular preload leads to a preferential flow to the left ventricle, related with reduced left ventricle compliance and raised left atria pressure[4]. The left ventricular evaluation is challanging due to large amount of functional reserve of the fetal myocardium, and since in the fetal circulation the ventricles are depend on each other, other parameter which reflect left atria(LA) dynamics should be considered. As pulmonary vein Doppler shows changes in left atria pressure, the Pulmonary vein pulsatility index (PVPI) is a good parameter to assess atrial dynamics [5]. Moreover, despite the protective reallocation of oxygenated blood towards the heart fetal hypoxia can cause cell damage and can be documented by reverse pulmonary vein 'a' wave [3].

Fetal echocardiography has evolved as the non invasive modality to assess fetal cardiac function. Pulmonary vein pulsatility index (PVPI) is an simply procured Doppler parameter that can be useful for the assessment of the left heart in IUGR fetuses.[3,5]

The objective of this study was to compare Pulmonary vein pulsatility index (PVPI) between Intra Uterine Growth Restricted Fetuses (IUGR) and Appropriate For Gestational Age (AGA) fetuses.

MATERIALS AND METHOD

This study was a prospective observational study conducted between april 2021 to july 2022 in the department of obstetrics and gynaecology, SMS medical college and attached hospital, Jaipur.

The study included two groups consisting of 40 women in each group.

Group A included > 28 weeks with IUGR due to placental insufficiency (fetal weight less than 10th percentile according to WHO was considered as IUGR)

Group B included > 28 weeks with AGA fetus.

Women with multiple pregnancy, congenital malformation and

pregnancy with chronic medical disorder were excluded. Approval from institutional research review board, and ethical committee was obtained.

Ultrasound and Doppler measurement were performed by ALOKA profound alfa -6 4D machine using 4-6 MHz curved transducers. Umblical artery pulsatility index (UMB-PI), middle cerebral arterial pulsatility index (MCA-PI), cerebroplacental ratio, were calculated. The PVPI was measured by a fetal echo cardiography.

The echocardiography was done by same senior cardiologist using Philips I.E. 33 matrix echocardiography machines as to avoid interobserver variations.

To analyze the pulmonary venous flow , the Doppler sample volume was placed at the right superior pulmonary vein adjacent to the venoatrial junction (distal position) in a 4 chamber view ,guided by color flow mapping or power angio-doppler with an angle of insonation <30 °. Scales of 0-20 cm/s and filters of 50-100hz were used and 3 measurement were obtained in apnea . In all fetuses, the PVPI was calculated after manual tracing of the pulmonary venous flow waveform

In all fetuses, the PVPI was calculated by:
Peak Systolic Velocity (cm/sec) -presystolic Velocity(cm/sec) /
Mean Averaged Maximum Velocity(cm/sec)

Stastical Analysis
Continuous variables were summarized as mean standard deviation, while nominal /categorical variables were summarized as proportion. Parametric test were used for continuous variable, whereas Chi-square test and Fischer exact test were used for nominal categorical variability. P value < 0.05 was taken as significant value.

RESULTS
The mean age of pregnant women was 25.02 + 3.51 years and 25.7 + 3.80 years in the study group and control group respectively (p value < 0.407). In study group, IUGR fetuses showed raised umbilical artery pulsatility index (UMB-PI), decreased middle cerebral artery pulsatility index (MCA –PI), decreased mean cerebroplacental ratio (C/P) ratio [table 1] compared with control group. Cerebroplacental ratio < 1 was associated with poor perinatal outcome.

Table 1 . Doppler Parameter

GROUP	UMB PI	MCA PI	C/P
IUGR GROUP	1.12±0.40	1.61 ±0.35	1.57 ±0.61
CONTROL GROUP	1.01±0.23	1.84 ±0.47	1.82±0.60
p value	0.728	0.044	0.372

The mean of Pulmonary Vein Palsatility Index in the study group was higher {1.23 +0.21} compared to the mean of Pulmonary Vein Palsatility Index in the Control group { 0.78 +0.13.} [table 2]

Table 2 Echocardiographic Parameter

Pulmonary Vein Palsatility Index	Group		Wilcoxon-Mann-Whitney U Test	
	Case	Control	W	p value
Mean (SD)	1.23 (0.21)	0.78 (0.13)	1572.000	<0.001
Median (IQR)	1.2 (1.08-1.38)	0.78 (0.69-0.88)		
Min – Max	0.89 - 1.62	0.28 - 1.2		

The factors that could predict IUGR independently were analyzed using multivariant logistic regression.(Table 3) The cut off value for PVPI for predicting cardiac dysfunction ≥ 0.96. Using this the sensitivity of PVPI for predicting IUGR and cardiac dysfunction was 95 % Specificity was 97.5 % PPV was 97.4 % NPV was 95 % which is better than other Doppler parameter. The diagnostic performance of PVPI {96.2%} is significantly better than both UMB PI {63.5%} and MCA PI {68.8%}

Table 3 Performance Of Study Parameters For Predicting IUGR

Variable	CUT OFF	Sensitivity	Specificity	PPV	NPV	Diagnostic Accuracy
UMB PI	≥1.5	30%	97.5%	92.3%	58.2%	63.7%
MCA PI	≤1.98	95%	42.5%	62.3%	89.5%	68.8%
PVPI	≥0.96	95%	97.5%	97.4%	95%	96.2%

The table 4 showed comparison of mean pulsatility index of various vessels between study group and control group at gestational age of 32-34 weeks, 35-36 weeks, and 37 weeks respectively.

Table 4 Comparison Of Various Doppler Parameter According To Gestational Age

GESTATIONAL AGE	Mean doppler pulsatality index	Group		Wilcoxon-Mann-Whitney U Test	
		Cases	Controls	W	p-value
32-34 weeks POG [2 cases, 3 controls]	MCA PI	2.15±0.01	2.30±0.70	2.0	0.800
	UMB-A PI	1.41±0.69	0.83±0.15	5.0	0.400
	PVPI	1.18±0.28	0.81±0.06	6.0	0.200
35-36weeks POG[16 cases, 14 controls]	MCA PI	1.63±0.41	1.59±0.39	126.0	0.573
	UMB-A PI	1.09±0.39	0.96±0.22	128.0	0.517
	PVPI	1.20±0.19	0.83±0.14	214.0	<0.001
≥37 weeks POG[22 cases, 23 controls]	MCA PI	1.55±0.28	1.93±0.43	119.5	0.002
	UMB-A PI	1.12±0.39	1.07±0.23	235.0	0.698
	PVPI	1.26±0.22	0.75±0.13	504.5	<0.001

The difference was no statiscally significant as compared to controls of various age group in umbilical artery pulsatility index and middle cerebral artery pulsatility index in early gestation. Whereas, there was a significant difference between cases and controls with regard to PVPI. Thereby, suggesting that PVPI better compared to UMB PI and middle cerebral artery pulsatility index for prediction of perinatal outcomes.

DISCUSSION
In placental inadequacy, the ventricular outflow tract resistance increases as the placental vascular resistance increases. This bring about a change in pulmonary venous flow. In circumstances in which the left ventricular compliance is decreased, the presystolic wave 'a – wave' of the pulmonary vein reduces , absent, or reversed and the PVPI increases[3].

Placental incompatibility is the most common cause of IUGR a situation in which the foetus is unable to grow at a normal velocity . There is insufficient blood flow to the foetus , which can cause nutrient and oxygen deficiency. It is likewise related with increased perinatal mortality, morbidity and various complexities, including perinatal acidosis, hypothermia, hypoglycaemia and coagulated abnormalities, chronic lung disease, necrotizing enterocolitis , cognitive delay and neurological disorder.[4]

Defective placental angiogenesis disturbs remaking of the spiral arteries and is proposed as the main pathophysiology inherent in placental inadequacy and fetal growth restriction[6]. Several predictors such as irregularity of the flow of the umbilical artery and ductus venosus determined via Doppler ultrasound have been reported in placental inadequecy that could reflect fetoplacental hemodynamics. In placental insufficiency, the umbilical artery pulsatility index increases and as cardiac dysfunction aggravates, the diastolic flow is absent or reversed. Reduced a- waves in the ductus venosus can be utilized as a measure of severe fetal hypoxia. However these veredicts are found in the late stage of placental inadequacy and could lead to missing the detection time for proper interventions. To upgrade perinatal consequences early predictors of placental insufficiency are required.[7]

In placental insufficiency fetal cardiac dynamics undergo a remodelling increasing uteroplacental vascular resistance . Placental inadequacy creates reallocation of oxygenated blood to the heart by shunting from the left ventricle[8]. In spite of preferential flow, fetal hypoxia or academia can cause cell damage. The myocardial performance index is associated with myocardial cell damage and is used as a tool to assess heart dysfunction[9]. Cruz- Martinez et al reported that an increase in the myocardial performance index (MPI) was a indicator of heart dysfunction in IUGR foetuses with normal umbilical artery Doppler findings[10]. In another study, MPI increased haster than the severity of ductus venosus or umbilical artery doppler findings in the early stages of foetal worsening in IUGR. The average changes in MPI took place about 3 weeks prior than ductus venosus indicating that MPI may be sensitive tool for foetal hypoxia at earlier stage.[11]

Pulmonary vein pulsatility index also increases as the compliance of the ventricles reduces when diastolic dysfunction happens. PVPI could be another parameter that considers myocardial performance.[3] Recently, it has been found that PVPI increases in IUGR associated with placental insufficiency.

Bravo Valenzuela et al[3] compared PVPI among IUGR foetuses and AGA foetuses, the PVPI of the IUGR group was 1.27 and that of AGA

was 0.75. As a result, only the IUGR group reveals higher PVPI compared with other group. They manifests that PVPI increased in IUGR foetuses with the normal flow in the ductus venosus.

The pulmonary venous flow considers left ventricle (LV) compliance and left atria (LA) pressure. Since dysfunction of LV preceds right cardiac dynamics, PVPI could be an early parameter for the detection of myocardial dysfunction in IUGR. The increase in other Doppler parameter like umbilical ,middle cerebral and ductus venosus manifests in late stages of detioration in IUGR. Possible clinical application for such Doppler indices are conditions with possibly defective left atrial function like heart defect with left atrial obstruction or late stages of severe IUGR .Moreover PVPI is relatively easy to obtain left myocardial function in IUGR. It is also not dependent on insonation angle [3].In our study we observed that the change in PVPI preceded other Doppler abnormalities such as umbilical artery and middle cerebral artery and PVPI have a better sensitivity and specificity compared to other Doppler parameters.

CONCLUSIONS

PVPI characterizes cardiac dysfunction, demonstrating subclinical cardiac dysfunction and cardiac remodelling in IUGR. It also helps in the prediction of postnatal cardiovascular heart disease and arterial remodelling better than perinatal severity parameter currently used. This study suggests that fetal echocardiography could be routinely incorporated into clinical practise for identification of fetuses at increased cardiovascular risk in high risk pregnancy that would benefit for lifestyle preventive strategies and potentially improve their future cardiovascular health.

Limitation

This study has some limitation first, bias can be caused by measurement by a single physician, Secondly it might have helped more if other parameters like myocardial performance index, ductus venosus etc which reflect the diastolic dysfunction of the ehart or cardiac motion were studied simultaneously. Lastly, larger prospective studies are required to further confirm our result and to evaluate the potential clinical value of PVPI.

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