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Original Research Article

Determining the Role of Second Trimester Umbilical Artery Doppler in Predicting Adverse Pregnancy Outcomes in a Low-Risk Population: An Observational Study

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Abstract

Aim: The aim of the present study was to determine the utility of second trimester umbilical artery Doppler velocimetry in the prediction of adverse perinatal outcomes (intrauterine growth restriction (IUGR), low birth weight (LBW) and stillbirth)

Material & Methods: One hundred low-risk nulliparous women with viable singleton pregnancies who met the inclusion criteria had umbilical artery Doppler assessment between 22 and 26 weeks gestation. RI≤ 0.76, PI≤ 1.36 and SD ≤ 4.52 were considered as normal. Each participant was monitored till delivery to assess outcome. Diagnostic performance of the Doppler indices for the prediction of adverse pregnancy outcomes were determined.

Results: The mean age of the participants was 31.19 ± 4.46 years and the mean gestational age at recruitment was 24.58 ± 1.42 weeks. Average systolic blood pressure at screening was 110.5±10.6 mmHg and the average diastolic blood pressure was 69.3±8.2 mmHg. Average birth weight of the babies was 3.02 ± 0.58 kg, 2/100 babies (2%) weighed >4kg at birth while 19/100 babies (19%) had low birth weight. At least one adverse pregnancy outcome occurred in 40/100 (40%) women. Of the 40 women, 8 (20%) had preeclampsia, 7 (17.5%) had pregnancy induced hypertension without proteinuria, 13 (26%) had intrauterine growth restriction, 20 (50%) had low birth weight fetuses, and there were 2 (5%) still-births. For any adverse pregnancy outcomes, sensitivity, specificity, positive predictive value (PPV) and negative predictive value (NPV) of abnormal umbilical Doppler parameters were 16.4%, 94.0%, 62.6% and 61.9% respectively. For stillbirth, the sensitivity, specificity, PPV and NPV of abnormal Doppler indices were 67.7%, 90.6%, 16.4% and 99.1% respectively. For IUGR the sensitivity and specificity of PI were 0.0% and 88.4% respectively, while PI had 13.0% sensitivity and specificity of 90.6% for LBW. For stillbirth, the sensitivity and specificity of PI were 66.4% and 91.7%.

Conclusion: Late second trimester umbilical artery Doppler velocimetry has a limited role in this low risk population for prediction of adverse pregnancy outcomes. The role of umbilical artery Doppler velocimetry in the prediction of adverse outcomes in high-risk pregnant women may be worthwhile.

Keywords: Adverse Pregnancy Outcomes, Umbilical Artery Doppler Velocimetry, Resistance Index, Pulsatility Index.

Introduction

Complications of pregnancy are often associated with an adverse event in the mother and the fetus. [1] Such complication may arise from preexisting maternal conditions that predate the pregnancy (chronic medical disorders and hemoglobinopathy) and previous obstetric problems. Others are maternal social and anthropometric characteristics (age, obesity) and health problems (pregnancy-induced hypertension, preeclampsia, eclampsia, anemia, and gestational diabetes) diagnosed during pregnancy, labor, and delivery. [1-3] Failure of pregnancies to establish low resistance circulations in the placenta has been reported to significantly increase the risk of adverse pregnancy outcomes such as preeclampsia, intrauterine growth restriction and low birth weight particularly in high-risk women. [4,5] Doppler ultrasound evaluation of the uterine and umbilical arteries has become an important clinical tool in screening pregnant women who could develop adverse

pregnancy complications or outcomes, [6-9] as high uterine and umbilical Doppler impedance and decreased blood flow are proven findings in pregnancies with adverse complications. [10] Doppler velocimetry of the umbilical artery is a non-invasive measure of fetoplacental hemodynamic state. Variations in umbilical artery Doppler indices such as pulsatility and resistance indices indirectly reflect the degree of impedance to flow in the fetoplacental circulation. Studies have reported a direct association between abnormal Doppler indices in the second trimester and fetal hypoxia, acidosis and adverse perinatal outcomes. [11]

Hence these indices have been suggested reliable screening tests for the identification of patients likely to develop IUGR, low birth weight, and stillbirth. The accuracy of prediction of adverse pregnancy outcomes using umbilical artery Doppler velocimetry has been reported to be a valuable tool in the prediction of adverse perinatal outcomes in high risk pregnancies, complicated by preeclampsia or IUGR. [12] However, the value of abnormal second trimester umbilical artery Doppler indices in low risk patients in the prediction of adverse perinatal outcomes still requires further research. In this study, we evaluated the utilization of both uterine and umbilical artery Doppler in detecting adverse pregnancy outcomes in each of the second and third trimesters, as well as determine the best Doppler parameter(s) that best predict adverse maternal and fetal complications and determine their degree of predictability among an unselected population of pregnant women.

Therefore, the aim of the present study was to determine the association between abnormal second trimester umbilical Doppler indices [pulsatility index (PI), resistance index (RI) and systolic/diastolic (SD) ratio] and adverse pregnancy outcomes in low risk nulliparous women.

Material & Methods

This was a prospective longitudinal study involving low risk nulliparous women with viable singleton pregnancies between 22 and 26 weeks gestational age attending Department of obstetrics and Gynaecology, JLN Medical College and Hospital, Bhagalpur, Bihar, India for the duration of 1 year (Dec 2016 to Nov 2017). A total of 100 women who met the inclusion criteria were enrolled in the study. Consecutive nulliparous women who met the inclusion criteria were educated about the study and written informed consent was obtained from study participants. Anonymity of patients' information was ensured during this study.

Inclusion criteria

All nulliparous women with viable singleton pregnancies at EGA 22-26 weeks and had low risk pregnancies attending Department of obstetrics and Gynaecology, JLN Medical College and Hospital, Bhagalpur, Bihar, India at the teaching hospital with intention to deliver in the same hospital were eligible to participate in the study. Study was approved by our institutional review board.

Exclusion criteria

Previous deliveries, history of hypertension, multiple gestations, and fetal structural anomalies in index pregnancy or those in whose gestational age was not reliable.

Methodology

Demographic and clinical information were obtained using a pretested study proforma: maternal age, religion, occupation, cigarette smoking, and alcohol intake, family history of preeclampsia and maternal height, weight and body mass index. Gestational age was calculated from the first day of the last menstrual period and confirmed by a first trimester ultrasound scan. The gestational age obtained from the first trimester scan was used in cases of discrepancy.

Umbilical Artery Doppler Ultrasound

All sonographic examinations were performed transabdominally with the woman in semi-recumbent position by a board-certified radiologist using a GE, Model - Logiq P3. Each patient first had a routine obstetric ultrasound scan, then umbilical artery Doppler flow spectrum was recorded from a free floating central part of the umbilical cord away from the placenta and fetal cord insertion.

The mean of three even velocity waveforms was 128 analysed for resistance Index (RI), pulsatility Index (PI) and systolic/diastolic SD ratio. RI≤ 0.76, PI≤ 1.36 and SD ≤ 4.52 were considered as normal based on 95th percentile cut off at average EGA of 24weeks in a similar population. [13] Results of the routine ultrasound scans were made available to the attending obstetrician, however the findings on Doppler velocimetry were stored in a secured database by the investigators and decisions on care were not subject to the interpretation of the Doppler ultrasound.

Obstetric Outcomes

All study participants were followed up in the antenatal clinics till delivery. Blood pressure, weight gain, symphysio-fundal height and urinary protein analysis were assessed at each antenatal visit. Obstetric complications, the mode of delivery and perinatal outcomes (APGAR scores, fetal distress, fetal death or neonatal intensive unit admission) were recorded. Adverse outcome was defined as development of intrauterine growth restriction at any gestational age, delivery of low

birth weight babies or intrauterine fetal death. Intrauterine growth restriction was defined as estimated fetal weight below the 10th percentile for the gestational age [14] Birth weight <2.5kg was defined as low birth weight. Each patient had standard obstetric care and the diagnoses were made by the attending physicians.

Statistical Analysis

All data were coded and entered into Statistical Package for Social Science (SPSS), Windows version 20.0; (Chicago, IL, USA). Descriptive statistics were summarized as frequencies and percentages. Means and standard deviations were also reported for continuous variables. To determine the screening ability of second trimester umbilical Doppler velocimetry indices for predicting the development of intrauterine growth restriction, delivery of a low birth weight neonate or stillbirth, sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV) were calculated. Additionally, Receiver Operating Characteristics (ROC) analysis was constructed and Area under the curve (AUC) was plotted to determine the association between umbilical artery RI, PI and SD ratio with intrauterine growth restriction, low birth weight and stillbirth. P-value of <0.05 was considered statistically significant.

Results

Table 1: Socio-demographic variables

Variable	Frequency	Percent
Age Group (years)		
< 35	80	80
≥ 35	20	20
Mean ± SD	31.19 ± 4.46	
Range	22 – 40	
Marital status		
Single	8	8
Married	92	92
Educational status		
Secondary	10	10
>Secondary	90	90
Occupation		
Housewife	18	18
Business	22	22
Professional	51	51
Artisan	5	5
Schooling	4	4
BMI(Kg/m^2)		
< 30.0	88	88
≥ 30.0	12	12
Mean ± SD	25.35±3.83	
Range	18.75-37.20	
EGA @ recruitment(weeks)		
Mean ± SD	24.58 ± 1.42	
Range	22-26	
Birth weight (kg)		
< 2.5	19	19
2.5-4.0	79	79
> 4.0	2	2
Mean ± SD	3.02 ± 0.58	
Range	1.00 – 4.60	
Blood pressure @ recruitment	SBP	DBP
Mean ± SD	110.5±10.6	69.3±8.2
Range	90-140	50-90

The mean age of the participants was 31.19 ± 4.46 years and the mean gestational age at recruitment was 24.58 ± 1.42 weeks. Average systolic blood pressure at screening was 110.5±10.6 mmHg and the average diastolic blood pressure was 69.3±8.2 mmHg. Average birth weight of the babies was 3.02 ± 0.58 kg, 2/100 babies (2%) weighed >4kg at birth while 19/100 babies (19%) had low birth weight.

Table 2: Pregnancy outcomes

Variable	Frequency	Percentage
Pregnancy outcomes		
Normal	60	60
Adverse pregnancy outcomes	40	40
Preeclampsia	8	20 (8/40)
Pregnancy induced hypertension	7	17.5 (7/40)
IUGR	11	27.5 (11/40)
LBW	20	50 (20/40)
Stillbirths	2	5 (2/40)

At least one adverse pregnancy outcome occurred in 40/100 (40%) women. Of the 40 women, 8 (20%) had preeclampsia, 7 (17.5%) had pregnancy induced hypertension without proteinuria, 13 (26%) had intrauterine growth restriction, 20 (50%) had low birth weight fetuses, and there were 2 (5%) still-births.

Table 3: Evaluation of diagnostic performance of abnormal umbilical artery Doppler indices in detecting adverse pregnancy outcomes

Abnormal umbilical artery Doppler	Composite Adverse Pregnancy Outcomes	IUGR	LBW	SB
Sensitivity	16.4	0.0	12.0	67.7
Specificity	94.0	88.9	88.4	90.6
PPV	62.6	0.0	24.1	16.4
NPV	61.9	87.7	78.4	99.1

For any adverse pregnancy outcomes, sensitivity, specificity, positive predictive value (PPV) For any adverse pregnancy outcomes, sensitivity, specificity, positive predictive value (PPV) and negative predictive value (NPV) of abnormal umbilical Doppler parameters were 16.4%, 94.0%, 62.6% and 61.9% respectively. For IUGR, the sensitivity, specificity, positive predictive value (PPV) and negative predictive value (NPV) of abnormal Doppler indices were 0.0%, 88.9%, 0.0% and 87.7% respectively while for LBW, the sensitivity, specificity, PPV and NPV of abnormal Doppler indices were 12.0%, 88.4%, 24.1% and 78.4% respectively. For stillbirth, the sensitivity, specificity, PPV and NPV of abnormal Doppler indices were 67.7%, 90.6%, 16.4% and 99.1% respectively.

Table 4: The association between the Umbilical PI, RI, SD and intrauterine growth restriction, delivery of low-birth-weight fetuses and stillbirth

Diagnostic Indices	Sensitivity (%)	Specificity (%)	PPV (%)	NPV (%)	AUC
RI 0.76					
IUGR	0.0	99.1	0.0	88.1	0.52
LBW	0.0	98.4	0.0	78.9	0.52
Stillbirth	0.0	99.1	0.0	95.5	0.50
PI 1.36					
IUGR	0.0	88.4	0.0	88.9	0.58
LBW	13.0	90.6	26.0	79.6	0.48
Stillbirth	66.4	91.7	16.8	99.1	0.23

For IUGR the sensitivity and specificity of PI were 0.0% and 88.4% respectively, while PI had 13.0% sensitivity and specificity of 90.6% for LBW. For stillbirth, the sensitivity and specificity of PI were 66.4% and 91.7%.

Discussion

Despite recent advances in antenatal care, preeclampsia remains the major cause of maternal and perinatal morbidity and mortality. So early screening of preeclampsia and fetal growth restriction may allow vigilant antenatal surveillance and appropriate timing of fetal delivery in order to avoid serious sequelae. Doppler techniques have been the focus of interest and research activity in obstetrics since the initial report of signals from the umbilical artery by Fitzgerald and Drumm. [15] The first application of Doppler velocimetry in obstetrics was reported by Fitzgerald and Drumm [15] and McCallum et al. [16] It has been long assumed that insufficient uterine, placental, and fetal circulations result in adverse pregnancy outcomes and that those abnormalities can be defined by the use of Doppler ultrasonography. [17]

The mean age of the participants was 31.19 ± 4.46 years and the mean gestational age at recruitment was 24.58 ± 1.42 weeks. Average systolic blood

pressure at screening was 110.5±10.6 mmHg and the average diastolic blood pressure was 69.3±8.2 mmHg. Average birth weight of the babies was 3.02 ± 0.58 kg, 2/100 babies (2%) weighed >4kg at birth while 19/100 babies (19%) had low birth weight. At least one adverse pregnancy outcome occurred in 40/100 (40%) women. Of the 40 women, 8 (20%) had preeclampsia, 7 (17.5%) had pregnancy induced hypertension without proteinuria, 13 (26%) had intrauterine growth restriction, 20 (50%) had low birth weight fetuses, and there were 2 (5%) still-births. Previous study evaluating the ability of umbilical artery Doppler indices in the prediction of IUGR reported sensitivities ranging from 61.5% to 73.8% and 42.9% to 61.0% for PI and RI respectively. [5,8,18]

Previous studies have suggested an association between abnormal umbilical artery Doppler indices and lower birth weight. [19-24] For any adverse pregnancy outcomes, sensitivity, specificity, positive predictive value (PPV) and negative predictive value (NPV) of abnormal umbilical Doppler parameters were 16.4%, 94.0%, 62.6% and 61.9% respectively. For stillbirth, the sensitivity, specificity, PPV and NPV of abnormal Doppler indices were 67.7%, 90.6%, 16.4% and 99.1% respectively. For IUGR the sensitivity and specificity of PI were 0.0% and 88.4% respectively, while PI had 13.0% sensitivity and specificity of 90.6% for LBW. For stillbirth, the sensitivity and specificity of PI were 66.4% and 91.7%. Although Torres et al [25] reported 62.5% sensitivity for RI in hypertensive pregnant women who delivered low birth weight babies, no similar results were found in this study.

The ability of late second trimester umbilical Doppler indices to predict adverse outcomes may be low in this low risk study population. It is important however to note that the negative predictive values of Doppler indices for prediction of adverse obstetric outcomes in this study was high and ranged between 78.9-99.1%. This may suggest that even though an abnormal umbilical artery Doppler does not have enough sensitivity to warrant intervention in these low risk population, it is suggested that adverse obstetric outcomes are unlikely in the presence of normal late second trimester umbilical Doppler indices.

Conclusion

Based on our results, there is a limited role for routine umbilical Doppler in low risk women between 22-26 weeks gestation for prediction of intrauterine growth restriction, delivery of low birth weight babies or stillbirth. Although a fetus may present with abnormal UA flow early in gestation, the progression of this abnormality over time is a much more accurate indicator of fetal outcome. The optimal gestational age for follow up UA Doppler may need to be explored in further studies evaluating the clinical utility of these indices in predicting pregnancy outcomes in these cohort of patients.

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