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Original Research Article

Prediction of perinatal outcome in high-risk pregnancy by Doppler ultrasound: a prospective cohort study

Zalak V. Karena[1]*, Aditya D. Mehta[2], Hetvee M. Vaghela[1], Harsh R. Shah[1]

[1]Department of Obstetrics and Gynaecology, [2]Department of Radiology, Pandit Deendayal Upadhyay Medical College, Rajkot, Gujarat, India

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***Correspondence:**
Dr. Zalak V. Karena,
E-mail: zkarenawork@gmail.com

ABSTRACT

Background: Doppler study of uterine and fetal vessels assesses the feto-maternal circulation. An abnormal Doppler study is a sign of placental dysfunction and fetal damage. This study aims to study the relationship of Doppler velocimetry of the uterine artery, umbilical artery, and middle cerebral artery to perinatal outcomes in normal and high-risk pregnancies.
Methods: A prospective cohort study was conducted in a tertiary health care center. A total of 150 patients aged 18–35 years with the gestational age of 28 to 40 weeks in 2 cohorts, 75 in high risk and 75 in the non-high-risk cohort were included. Pregnant women with gestational hypertension, intrauterine growth restriction, preeclampsia, preeclampsia plus IUGR were included in high-risk cohort. Doppler study was carried out, data was collected, and was analyzed.
Results: Doppler parameters and their association with perinatal outcome were measured. The sensitivity of umbilical artery index (79.4%) was found to be highly predictive of poor neonatal outcomes compared to middle cerebral artery Doppler (58.8%) and cerebroplacental ratio (41.2%) parameters. A high positive predictive value for unfavourable perinatal outcomes with an accuracy of 93% using umbilical artery indices, 95% using MCA Doppler, and 93% CPR was found in the study. Specificity of umbilical artery Doppler was 87.5%, MCA Doppler was 93.75% and CPR was 93.75%.
Conclusions: When incorporated into evaluating high-risk pregnancies complicated by pregnancy-induced hypertension, preeclampsia, and IUGR in the third trimester, screening the fetuses for well-being with Doppler helps in timely intervention and improves the perinatal outcome.

Keywords: Doppler, High-risk pregnancies, Perinatal, Intrauterine growth restriction

INTRODUCTION

The primary objective of obstetric management is to identify pregnancies at risk of avoidable perinatal morbidity and death. Pregnancy development is normal when nutrients and oxygen are provided in an adequate amount. The uterine and umbilical arteries are the primary conduits of blood to the fetus. The goal of obstetric care is to identify women who are at high risk of pregnancy-related illness or mortality. Pregnancy needs a sufficient intake of food and oxygen. Both the uterine and umbilical arteries supply blood to the developing fetus throughout pregnancy.[1] Pregnancies with high blood pressure or a fetal growth restriction have compromised umbilical and uterine blood flow.[2,3] Five to ten percent of pregnancies are complicated by hypertensive problems

and is among the three leading causes contributing to maternal and perinatal illness and death.[4] Vasospasm and endothelial dysfunction contribute to decreased organ perfusion in preeclampsia. The brain, liver, kidney, and placenta are all involved in nearly all cases of morbidity. IUGR, a common side effect of PIH, is caused by a failure of normal placental invasion and development.[5] Immediately following fertilization, the flow of uterine blood increases from 50 to 500 to 700 ml/min. It has a peculiar Doppler waveform shape, with a diastolic velocity that is nearly identical to systole and a very turbulent flow. Indicators fall as the term draws near because diastolic velocity rises. A lack of pattern or notch at the end of systole is linked to fetal growth restriction.[6,7] In obstetrics, Doppler ultrasonography represents a big advancement. Abnormal Doppler readings are a sign of prenatal growth restriction and stress on the fetus. It is a sign of placental dysfunction and fetal damage if there is no diastolic flow or if it is reversed in blood vasculatures feeding foetus.[8] Umbilical artery in terms of non-invasive fetal testing has validated its significance. Umbilical artery end-diastolic velocity decreases due to high flow resistance in terminal villi. There was a tendency toward lower perinatal mortality when Doppler velocimetry was used in randomized controlled studies in high-risk pregnancies (mainly those with PIH and likely IUGR).[9,10] A Doppler assessment of cerebral blood flow can reveal aberrant circulation before hypoxemia affects the fetal heart rate. The pulsatility index of the middle cerebral artery diminishes as hypoxia progresses.[11] Our study aimed at screening the cases of high-risk pregnancy and normal pregnancy with Doppler scans in the third trimester between 28 and 40 weeks of pregnancy and understand the role of Doppler ultrasound in predicting a poor perinatal outcome and in the therapeutic management of high-risk pregnancies.

METHODS

A prospective cohort study was carried out in the Department of obstetrics and gynaecology of PDU medical college, Rajkot from July 2021 to December 2021.

Patients who met the inclusion criteria for the department of obstetrics and gynaecology were allocated to one of two cohorts, A or B, with a 1:1 ratio. Pregnant women with high-risk pregnancies were included in cohorts A and B included women with normal (non-high risk, control cohort) as controls.

Inclusion criteria

Patients in the age group of 18 to 35 years, with a gestational age of 28 to 40 weeks. Pregnant women with gestational hypertension, IUGR, preeclampsia, preeclampsia plus IUGR. Only the ones who consented to the study were included.

Exclusion criteria

Patients with grand multiparity, multiple gestations, cardiovascular or renal disease, chronic hypertension, and fetuses with congenital anomalies (already detected via scans) were excluded.

Sample size

Total 75 high-risk pregnancies with inclusion criteria and an equal number of normal pregnancies were studied from July 2021 to December 2021.

Procedure

For all pregnant women satisfying the inclusion criteria, after obtaining a clinical history, completing a clinical examination, and obtaining an ultrasound, the subjects were exposed to a Doppler examination. A Doppler waveform was collected for the umbilical, uterine, and middle cerebral arteries and several indices were determined. Pulsatility Index and Resistance Index were measured. It was considered abnormal if the Doppler parameters for uterine, umbilical, and middle cerebral artery turned out to be less than the 5th percentile for gestational age. There was just one threshold for CPR=MCA PI/UA PI (1.0). CPR>1 was normal; CPR<1 was not. Investigations were carried out, including hematological, biochemistry, urine analysis, radiologic, non-stress tests, fundoscopy, and color Doppler. Other investigations were carried out as and when required. Fetal parameters such as gender, birth weight, time of birth, date of birth, admission to NICU, APGAR score at 5 min, need for positive pressure ventilation, and survival status (live born, stillborn, or perinatal deaths) were recorded.

Outcome criteria

Pregnancy outcomes were predicted using Doppler findings from the umbilical, uterine, and middle cerebral arteries. "Adverse" pregnancies are defined as those in which any of the following conditions are present: An Apgar score of less than 7 at 5 minutes, an emergency C-section due to fetal distress, and a fetal death. When the foregoing difficulties were not present, the pregnancy result was judged to be either uncomplicated or positive. To determine the outcome of each pregnancy, the records of the labor ward and the neonatal critical care unit were collected.

Statistical analysis

Data was analyzed using SPSS 24.0. The Chi-Square test was used to analyze categorical dependent and independent variables. 0.05 was statistically significant.

RESULTS

The age group studied was between 18 to 35 years. 41.35% of women in the high-risk cohort and 40% in the control cohort were of 19 to 24 years. 44% of women in the high-risk cohort and 46.65% of controls were of the age group 25 to 29 years. The majority of the study subjects were primigravida which accounted for 35 (46.65%) women in the high-risk cohort and 38 (50.65%) in the control cohort. Out of 75 high-risk pregnancies, 20 (26.65%) women in the high-risk cohort were complicated with gestational hypertension, 27 (36%) with IUGR, 9 (12%) had anemia, 3 (4%) were Rh negative pregnancies, pre-eclampsia was in 7 (9.35%) and severe pre-eclampsia in 9 (12%) of women in a high-risk cohort (Figure 1). Placental maturity of grade 2 was present in 33 (44%) women in the high-risk cohort, and in 56 (74.65%) among controls. Placental maturity of Grade 3 was present in 42 (53%) patients among women in the high-risk cohort, and 19 (25.35%) among controls, which is statistically significant ($p<0.05$). High-risk pregnancy women had a higher grade of placental maturity. Out of 37 women in the high-risk cohort who had oligohydramnios, 35 (55.55%) had abnormal Doppler and 2 (16.65%) had normal Doppler findings. Among 38 women who had normal AFI, 28 (44.45%) had abnormal Doppler and 10 (83.35%) had normal Doppler findings. Out of 26 women in a high-risk cohort with a CP ratio ≤1, 24 (64.85%) had Intrauterine growth restriction, and 2 (5.25%) cases had normal growth. Among 49, with CP ratio >1, only 13 (35.15%) had IUGR and 36 (94.75%) had normal growth. Out of 75 babies born to high-risk women, 61 (81.35%) required NICU admission, and 14 (18.65%) did not require NICU admission, which is statistically significant ($p<0.05$). Out of 7 women in the study, which showed absent end diastolic flow, 03 (43%) had perinatal mortality. Both women showing reversal of diastolic flow had perinatal mortality (100%) ($p<0.05$). All women in the non-high-risk cohort had normal Doppler findings. Among 75 women in the high-risk cohort, 63 (84%) patients had abnormal Doppler indices in either one or combination among three vessels. 12 (16%) patients had normal Doppler findings (Table 1). Among 75 women in the high-risk cohort, 56 (74 %) cases had abnormal doppler indices in the umbilical artery, 27 (36 %) cases had abnormal Doppler indices in the uterine artery and 41 (55%) cases had abnormal Doppler indices in the middle cerebral artery. 96 % of women with abnormal Doppler findings in the high-risk cohort had adverse perinatal outcomes and 3.35 % with normal Doppler findings had an adverse perinatal outcome. Various Doppler indices and their association with perinatal outcomes in the study. Umbilical artery indices were highly sensitive to predicting the adverse perinatal outcome and MCA indices and CPR were specific to diagnosing poor perinatal outcomes (Table 3). Among 12 high-risk women with normal Doppler findings, 9 (75%) high-risk women had a vaginal delivery. Out of 63 high-risk women who had abnormal Doppler findings, 49 (77.77%) high-risk women had LSCS as their mode of delivery ($p<0.05$). Of the 63 high-risk women with aberrant Doppler results, 9 had birth weights between 1 and 1.5 kg, 12 had birth weights between 1.5 and 2.0 kg, 23 high-risk women had birth weights between 2.1 and 2.5 kg, and 14 high-risk women had birth weights between 2.5 and 3.0 kg. The birth weights of two of the 63 instances with normal Doppler results were 1.5 to 2.0 kg, seven high-risk women were between 2.1 and 2.5 kg, two high-risk women were between 2.5 and 3.0 kg, and one case was more than 3.0 kg. Those with abnormal Doppler were more likely to have kids with low birth weights, whereas those with normal Doppler were more likely to have normal birth weights. Poor APGAR score, the requirement of PPV, low birth weight, and higher perinatal death in the high-risk cohort compared to the control cohort (Table 4). This poor perinatal outcome in a high-risk cohort can be screened and predicted by Doppler and timely intervention can improve perinatal morbidity and mortality (Table 1-3).

Table 1: Doppler parameters between the two cohorts (n=75).

Doppler indices	High-risk cohort, N (%)	Control cohort, N (%)	P value
Abnormal	63 (84)	0	<0.001
Normal	12 (16)	75 (100)	
Total	75 (100)	75 (100)	

Table 2: Doppler parameters and perinatal outcome in the high-risk cohort.

Variables	Adverse perinatal outcome		Uneventful (normal perinatal outcome)		Total	P value
	N	%	N	%		
Umbilical artery Doppler abnormal	53	94.6	3	5.3	56	<0.00001
Umbilical artery Doppler normal	7	37	12	63	19	
Middle cerebral artery Doppler abnormal	38	92.6	3	7.3	41	<0.00001
Middle cerebral artery Doppler normal	10	29.4	24	70.5	34	
CPR abnormal	24	39.35	2	14.3	26 (100)	0.075
CPR normal	37	60.65	12	85.7	49 (100)	

Table 3: Doppler parameters in predicting perinatal outcome.

Parameters	Sensitivity (%)	Specificity (%)	PPV (%)	NPV (%)	DA (%)
Umbilical artery indices	79.4	87.5	93.1	66.65	55
MCA Doppler indices	58.8	93.75	95.25	51.7	47
Cerebroplacental ratio	41.2	93.75	93.35	42.85	39

PPV-positive predictive value, NPV- negative predictive value, DA-diagnostic accuracy

Table 4: Comparison of perinatal outcome in both the cohorts.

Perinatal outcome	APGAR score	High risk cohort, N (%)	Control cohort, N (%)	P value
APGAR score	>7	58 (77.35)	75 (100)	<0.00001
	<7	17 (22.65)	0	
PPV	Not required	54 (74)	75 (100)	<0.00001
	Required	21 (26)	0	
Birth weight (kg)	≥2.5	17 (22.65)	69 (92)	<0.00001
	<2.5	58 (77.35)	6 (8)	
Perinatal death	Yes	5 (6.65)	0 (0)	0.02
	No	70 (93.35)	75(100)	
Total		75	75	

Table 5: Doppler in predicting adverse perinatal outcome as compared with other studies.

Variables		Konareddy et al.[14]	Gramellini et al.[15]	Fong et al.[16]	Present study
Umbilical artery Doppler	Sensitivity	66.6	64	44.7	79.4
	Specificity	93.1	90.7	86.6	87.5
	PPV	87.5	72.7	54	93.1
	NPV	79.4	86.7	81.7	66.65
Middle cerebral artery Doppler	Sensitivity	83.3	24	72.4	58.8
	Specificity	85	100	58.1	93.75
	PPV	89.28	100	33.7	95.25
	NPV	77.27	77.30	85.7	51.7
Cerebroplacental ratio	Sensitivity	95	68	51.3	41.2
	Specificity	83	98.4	80.6	93.75
	PPV	88	94.4	48.1	93.35
	NPV	85	88.8	82.5	42.85

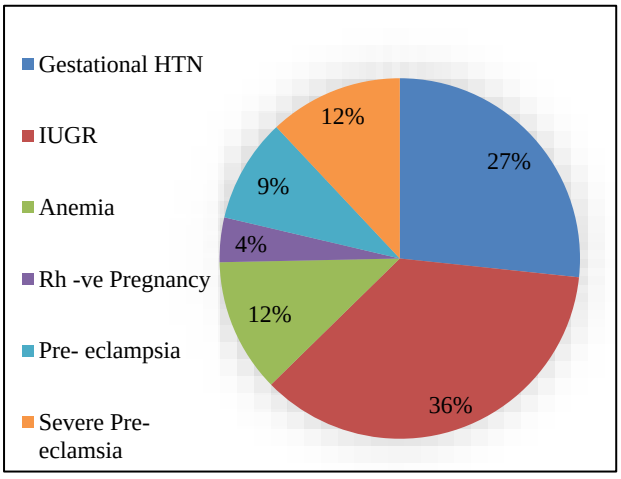

Figure 1: Distribution of cases as per the complications.

DISCUSSION

The study enforces, that high-risk pregnancy has a strong association with abnormal Doppler findings, and abnormal Doppler findings strongly co-relate to poor perinatal outcomes. As in the study done, screening of high-risk pregnancies in the third trimester for adequacy of feto-maternal circulation by Doppler allows timely intervention by the obstetrician to improve perinatal outcome. Our study, in concurrence with the observations in literature written by Bhatt et al, Gupta et al and Konareddy et al also found that the high-risk cohort had a higher number of abnormal doppler than normal.[12-14] In the present study, 16% of high-risk women had normal doppler findings and 84% of high-risk women had abnormal Doppler findings. The diagnostic accuracy as determined in our study compared to studies by Konareddy et al, Gramellini et al and Fong et al.[14-16]

The rate of LSCS among the high-risk cohort was 69%. Vaginal delivery was 31%. The rate of LSCS among controls was 26% and vaginal delivery was 74%.

The most common indication for LSCS was fetal distress (65.4%) and severe oligohydramnios (15.38%) formed the second most common cause among high-risk women. This result suggests that active surgical interventions in form of cesarean section are demanded in the high-risk cohorts as the compromised fetal circulation dreads fetal asphyxia and distress. According to Mikovic and colleagues, for the high-risk group, the average birth weight was 1572 grams, and the rate of maternal death was 14.3%.[17] In the current study, in the high-risk group with abnormal Doppler indices, was discovered a 1974-gram average birth weight and a perinatal death rate of 3.33 percent. The diagnostic accuracy of Doppler in our study compared to other studies is depicted in (Table 5).

Limitations

Limitations of current study were; the study was conducted in a small group of patients. Larger sample size is required to generalize the findings of the study. Ductus venosus and Tricuspid valve Doppler study was not included which has now emerging value in determining perinatal outcome.

CONCLUSION

Doppler study is a noninvasive method for assessing the hemodynamic function of the fetus and mother. There is a direct correlation between high-risk pregnancy with abnormal Doppler findings in the umbilical, middle cerebral artery, and CPR compared to non-high-risk pregnancies.

Hence, pregnant women with hypertension and documented IUGR can benefit from Doppler velocimetry because changes in uterine, umbilical, and fetal middle cerebral artery circulation strongly correlate with postnatal prognosis. The routine use of Doppler scans for screening of fetal well-being during the third trimester in high-risk pregnancies of preeclampsia, and intrauterine growth restriction (IUGR) helps to decrease perinatal morbidity and mortality.

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