Original Research Article

Significance of obstetric Doppler studies in prediction of perinatal outcome in pregnancy induced hypertension

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ABSTRACT

Background: Pregnancy induced hypertension (PIH) is associated with adverse perinatal outcome. Multi vessel color Doppler studies are useful in these cases for timely intervention. The aim of present study was to know the significance of umbilical, middle cerebral and uterine artery Doppler studies in PIH and to analyse its role in predicting perinatal outcome.

Methods: This was a prospective study of 106 singleton pregnancies in the third trimester with PIH. The results of last Doppler ultrasound within one week of delivery were used for analysis. Adverse perinatal outcome was studied in the form of emergency cesarean section for fetal distress, meconium stained amniotic fluid, Apgar at 5 min <7, NICU admission and perinatal mortality (stillbirths and neonatal death). Sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV) and diagnostic accuracy of various Doppler parameters were calculated after comparing with standard.

Results: In the present study specificity and diagnostic accuracy of all Doppler ultrasound parameters was high in predicting adverse perinatal outcome. Cerebroplacental ratio showed highest specificity (98.55%), PPV (94.44%) and diagnostic accuracy (80.19%) in predicting adverse perinatal outcome and it is better than MCA PI and UA PI alone. Uterine artery Doppler evaluation also gives additional information in predicting adverse perinatal outcome.

Conclusions: Amongst various Doppler parameters cerebroplacental index (MCA/UA PI) is best predictor of adverse perinatal outcome.

Keywords: Cerebroplacental ratio, Color doppler, Perinatal outcome, Pregnancy induced hypertension

INTRODUCTION

Hypertensive disorders during pregnancy remain the most common medical complications, leading to a majority of adverse perinatal and maternal outcome, despite numerous efforts have been made at early diagnosis, prevention and treatment.

The incidence of various hypertensive disorders of pregnancy varies widely from 5 to 15% with perinatal mortality of 15 to 20% in the developing countries.[1,2]

Preeclampsia is associated with altered uteroplacental circulation which may in turn affects the fetal growth as well as fetal hypoxia leading to adverse perinatal outcome. The abnormal vascular resistance to blood flow in the uteroplacental and fetoplacental circulation can be well studied by Doppler ultrasound. Color Doppler studies provides a repetitive, non-invasive tool for hemodynamic monitoring of the fetal wellbeing.[3] These vascular Doppler analyses predominantly plays role in decision making process in high risk obstetric cases.[4,5] Even though uterine artery Doppler is predominantly

used for screening of preeclampsia, its evaluation was included as it gives idea about maternoplacental circulation and to study correlation with the adverse perinatal outcome.

The aim of present study was to know the significance of umbilical, middle cerebral and uterine artery Doppler in pregnancy induced hypertension and to analyse their role in predicting perinatal outcome.

METHODS

The study comprised of 106 patients admitted in a tertiary care center at or beyond 28 weeks of gestation with pregnancy induced hypertension during two years' period.

Inclusion criteria were singleton pregnancy at or more than 28 weeks clinically diagnosed as pregnancy induced hypertension. Exclusion criteria were multiple gestation, congenital anomalies of the fetus, chronic hypertension, intrauterine death at the time of first Doppler examination and patients who cannot be followed up.

PIH is defined as rise of blood pressure ≥140/90 mmHg after 20 wks. gestation with proteinuria ≥300 mg/24 hours or ≥+1 on dipstick.

Informed consent was taken from all patients. Detailed history and clinical examination was done. All these patients were subjected to various investigations. Detailed ultrasound examination with Doppler studies were done using G E LOGIQ P3 C5-2E ultrasound machine with curvilinear probe of transducer frequency 3.5 MHz. The patients were allowed to rest for 10 to 15 minutes in a semi-recumbent position prior to commencing the ultrasound evaluation. Doppler waveform analysis of umbilical artery (UA), middle cerebral artery (MCA) and uterine artery (UtA) was done. The waveforms were obtained during fetal inactivity and apnoea.

Umbilical artery Doppler flow velocity waveforms were obtained from a free loop of cord. Middle cerebral artery was insolated at the level of the greater wing of sphenoid. Systolic flow (S) and diastolic flow (D) for the above-mentioned arteries were obtained to calculate various Doppler indices. The flow velocity waveforms obtained from the umbilical and middle cerebral were computed automatically. The program identified individual cardiac cycles and computed peak systolic velocity, end diastolic velocity, mean velocity and resistance index (RI), Pulsatility index (PI) and systolic/diastolic ratio (S/D).

Umbilical artery S/D ratio was considered abnormal when it was more than 3 after 30 weeks' gestation. Umbilical artery RI and PI were considered abnormal when it was more than the 95th percentile of the range of reference. Absent and reverse end diastolic flow of umbilical artery Doppler were considered abnormal.

Middle cerebral artery RI and PI were considered abnormal when it was more than the 95th percentile of the range of reference.

Cerebroplacental ratio or MCA / UA PI Ratio: This Doppler index is useful in identifying fetuses with increased placental and/ or decreased cerebral resistance. In the present study, a single cut off value 1.08 is used below which it is considered as abnormal.

Uterine arteries were identified with color Doppler shortly after its origin when it crosses the internal iliac artery. Both Uterine arteries are assessed to avoid biases due to lateral placental implantation. Uterine artery flow waveforms were considered abnormal with the presence of early diastolic notch and S/D ratio of more than 2.6 in any one either right or left uterine artery.

Follow up Doppler studies were performed if indicated to determine and monitor a favorable or worsening fetal wellbeing status. However only the results of last Doppler ultrasound within one week of delivery were used for analysis.

Further management of the cases were decided to depend on the clinical status of the patient and the Doppler report. The pregnancies were terminated according to obstetric indications. Patients are followed up till delivery. Further the maternal and perinatal outcome were studied.

Adverse perinatal outcome was classified based on the following outcome variables such as

- Emergency cesarean section for fetal distress
- Meconium stained amniotic fluid
- Apgar at 5 min <7
- NICU Admission
- Perinatal mortality (stillbirths and neonatal death)

Statistical analysis was done with the help of SPSS Software and Open Epi software. Sensitivity, Specificity, Positive Predictive Value (PPV), Negative Predictive Value (NPV) and Diagnostic accuracy is calculated for study variables after comparing with standard.

RESULTS

The study comprised of 106 cases of pregnancy induced hypertension with 78.3% having mild and 21.7% having severe hypertension. Age of the patients in the study ranged from 20-37 years with a mean age of 26.91 years. There were 54.72% primigravidas. Maximum number of patients belonged to term gestation (74.53%). In the present study 44 (41.5%) patients required induction of labour. Cesarean section was required in 52.83% patients. Out of the total 106 babies, 34.9% babies were low birth weight (<2.5 Kg). (Table 1)

Table 1: Maternal and fetal characteristics of study population (n=106).

Characteristics	Number	Percentage
Parity		
Primi	58	54.72
Multi	48	45.28
Severity of hypertension		
Mild	83	78.3
Severe	23	21.7
Gestational age		
28-32 weeks	5	4.71
33-36 weeks	22	20.75
>37 weeks	79	74.53
Mode of delivery		
Vaginal	50	47.17
Cesarean section	56	52.83
Birth weight (grams)		
<1500 gm	7	6.60
1500-2499 gm	30	28.30
≥2500 gm	69	65.09

Perinatal outcome was abnormal in 37 (34.9%) patients. More than one adverse outcome was observed in 13 cases. Amongst the cases with adverse perinatal outcome, 45.94% babies had meconium stained amniotic fluid and same number of cases had low Apgar score. 40.54% babies required NICU admission due to various reasons like birth asphyxia, low birth weight, prematurity etc. There were 3 (8.1%) perinatal deaths, two were stillbirths and one baby died in NICU on 9th day due to prematurity and sepsis. (Table 2). Umbilical Artery Doppler studies revealed 20.75% had abnormal S/D ratio, 26.42% had abnormal RI and 15.09% had abnormal PI.

Table 2: Adverse perinatal outcome (n=37).

Outcome parameter	Number	Percentage
LSCS for fetal distress	12	32.43
Meconium stained liquor	17	45.94
Apgar at 5 minute <7	17	45.94
NICU admission	15	40.54
Perinatal death	03	8.10

Fetal middle cerebral artery Doppler studies revealed 10.4% patients had abnormal MCA S/D ratio, 7.5% had abnormal MCA RI and 16.98% had abnormal MCA PI. Perinatal mortality was seen maximum in abnormal MCA S/D ratio (66.7%) followed by MCA PI (33.3%). Apgar score at 5 minutes less than 7 was seen maximum in patients with abnormal MCA S/D ratio (47.1%).

Table 3: Distribution of various color doppler findings (n=106).

Doppler parameter	Normal	Abnormal
UA S/D ratio	84	22
UA R.I.	78	28
UA P.I.	90	16
MCA S/D ratio	95	11
MCA R.I.	98	8
MCA P.I.	88	18
P.I. of MCA/UA	88	18
UtA S/D ratio	90	16
Ut.Art. notch	78 (Absent)	28 (Present)

Table 4: Association of doppler parameter with perinatal outcome.

Parameter		Adverse outcome	Good outcome
UA S/D ratio	Abnormal (n=22)	15 (True positive)	7 (False positive)
	Normal (n=84)	22 (False negative)	62 (True negative)
UA R.I.	Abnormal (n=28)	14 (True positive)	14 (False positive)
	Normal (n=78)	23 (False negative)	55 (True negative)
UA P.I.	Abnormal (n=16)	11 (True positive)	5 (False positive)
	Normal (n=90)	26 (False negative)	64 (True negative)
MCI S/D ratio	Abnormal (n=11)	9 (True positive)	2 (False positive)
	Normal (n=95)	28 (False negative)	67 (True negative)
MCA R.I.	Abnormal (n=8)	4 (True positive)	4 (False positive)
	Normal (n=98)	33 (False negative)	65 (True negative)
MCA P.I.	Abnormal (n=18)	8 (True positive)	10 (False positive)
	Normal (n=88)	29 (False negative)	59 (True negative)
MCA/UA P.I. ratio	Abnormal (n=18)	17 (True positive)	1 (False positive)
	Normal (n=88)	20 (False negative)	68 (True negative)
UtA S/D ratio	Abnormal (n=16)	9 (True positive)	7 (False positive)
	Normal (n=90)	28 (False negative)	62 (True negative)
UtA notch	Abnormal (n=28)	21 (True positive)	7 (False positive)
	Normal (n=78)	16 (False negative)	62 (True negative)

The diagnostic accuracy of umbilical artery S/D ratio in prediction of adverse perinatal outcome in the present study was found to be 72.64% compared to UA RI (65.09%) and UA PI (70.75%). Umbilical artery PI was having the highest specificity (92.75%) than UA S/D ratio (89.86%) and UA RI (79.71%) in prediction of adverse perinatal outcome. Out of 106 patients 4 patients had absent end diastolic flow (AEDF) and 3 had reverse end diastolic flow (REDF).

Cerebroplacental ratio (MCA PI/UA PI) was found to be most specific (98.55%) in predicting adverse perinatal outcome. All babies with perinatal deaths were having abnormal cerebroplacental ratio. In the present study, the cerebroplacental index has the highest specificity and positive predictive value 98.55% and 94.44% respectively in predicting adverse perinatal outcome, compared to that of Umbilical artery Pulsatility index (92.75% and 68.75%) and MCA Pulsatility index (85.51 and 44.44%).

Table 5: Efficacy of various doppler parameters in predicting adverse perinatal outcome.

Doppler findings	Sensitivity (%)	Specificity (%)	PPV (%)	NPV (%)	Diagnostic accuracy (%)
UA S/D	40.54	89.86	68.18	73.81	72.64
UA RI	37.84	79.71	50	70.51	65.09
UA PI	29.73	92.75	68.75	71.11	70.75
MCA S/D	24.32	97.1	81.82	70.53	71.7
MCA RI	10.81	94.2	50	66.33	65.09
MCA PI	21.62	85.51	44.44	67.05	63.21
MCA/UA PI	45.95	98.55	94.44	77.27	80.19
UtA S/D ratio	24.32	89.86	56.25	68.89	66.98
UtA notch	56.76	89.86	75	79.49	78.30

Total 16 (15.09%) patients had abnormal uterine artery S/D ratio. Uterine artery early diastolic notch was found in 26.4%.

DISCUSSION

The role of Doppler ultrasound to understand the uteroplacental and fetoplacental circulation in pregnancy induced hypertension is well studied by various researchers. In a normal pregnancy, there is a low resistance in uteroplacental and fetoplacental circulation. Pregnancy induced hypertension is associated with defective trophoblastic invasion which further leads to abnormal placental vascular flow. Doppler studies help in detecting the abnormal vascular resistance patterns in compromised fetuses so that timely intervention can be done.

The mean age of the mother in present study is 26.9 years. In similar studies by Smitha et al and Ozeren et al, they reported mean age as 23.4 and 27.6 years respectively.[6,7] In the present study 54.72% of the patients were primigravidas where as in the studies by Mohd Khalid et al and Lakhkar BN 77.7% and 60.3% patients were primigravida respectively.[8,9] The average gestational age at the time of delivery was found to be 37.29 weeks, whereas in the studies by Ozeren et al and Mohd Khalid et al it was 36.63 and 37.44 respectively.[7,8] The average birth weight in present study is 2508.20 grams, whereas in the studies by Ozeren et al Mohd Khalid et al and Lakhkar BN et al it is reported as 2356 grams, 2440 grams and 1798.70 grams respectively.[7-9]

The average birth weight appears to be lower in the study done by Lakhkar BN et al since they have included cases of severe preeclampsia and IUGR.[9]

Umbilical artery doppler studies:

The umbilical artery Doppler is an index of resistance to flow in the fetoplacental circulation and has a strong correlation with the presence or absence of fetal hypoxia and acidosis. In cases of placental vascular insufficiency diastolic flow decreases causing the umbilical artery S/D ratio to increase to values 2SD or higher above the mean for the gestational age. With progression of placental vascular insufficiency there will be absent diastolic flow (AEDF) followed by reverse diastolic flow (REDF) which is an ominous sign indicating the presence of fetal hypoxia and need to deliver the fetus.[10] Umbilical artery Doppler is considered abnormal if the S/D ratio is above the 95th percentile for the gestational age. S/D ratio decreases from a mean of 3.08 at 28 weeks to 2.1 at 40 weeks. The mean value of RI also decreased from 0.67 at 28 weeks to 0.52 at 40 weeks. PI value fell from 1.02 at 28 weeks to 0.69 at 40 weeks.[8]

In present study UA S/D ratio showed a higher specificity and diagnostic accuracy (89.86% and 72.64%) in predicting adverse perinatal outcome (Table 6).

In the study by Lakhkar BN et al the sensitivity, specificity, positive predictive value (PPV) and negative predictive value (NPV) of Umbilical Artery RI to predict adverse perinatal outcome was 44.4%, 81.8%, 80% and

47.3% respectively.[9] The higher specificity of 79.71% in predicting the adverse perinatal outcome in present study is comparable with this study. The specificity and diagnostic accuracy of Umbilical artery PI in prediction of adverse perinatal outcome of present study is comparable with studies done by Smitha et al Ozeren et al Lakhkar BN et al Gramellinni et al and Yoon et al and (Table 7).[6,7,9,11,12]

Table 6: Comparison of UA S/D ratio in predicting adverse perinatal outcome.

Umb. Art. S /D ratio	Ozeren et al[7]	Lakhkar BN et al[9]	Kofinas et al[17]	Present study
Sensitivity	88%	66.6%	71%	40.54%
Specificity	97%	45.4%	93%	89.86%
PPV	98%	66.6%	83%	68.18%
NPV	92%	45.4%	90%	73.81%
Diagnostic accuracy	94%	-	-	72.64%

Table 7: Comparison of UA P.I. in predicting adverse perinatal outcome.

Study	Umbilical artery P.I.				
	Sensitivity	Specificity	PPV	NPV	Diagnostic accuracy
Smitha et al	90.26%	80.57%	82.24%	88.35%	84%
Ozeren et al	69%	97%	95%	81%	85%
Lakhkar BN	50%	59%	66.6%	41.9%	-
Gramellini et al	64%	90.7%	72.7%	86.7%	83.3%
Yoon et al	89%	86%	86%	89%	-
Present study	29.73%	92.75%	68.75%	71.11%	70.75%

Table 8: Comparison of cerebroplacental index in predicting adverse perinatal outcome.

Study	Cerebroplacental ratio- MCA / UA PI				
	Sensitivity	Specificity	PPV	NPV	Diagnostic accuracy
Smitha et al	94.42%	82.65%	86.42%	96.41%	90%
Ozeren et al	81%	89%	84%	86%	85%
Gramellini et al	68%	98.4%	94.4%	88.8%	90%
Fong KW et al	51.3%	80.6%	48.1%	82.5%	-
Shahinaj R et al	98%	66%	30.8%	99.7%	-
Present study	45.95%	98.55%	94.44%	77.27%	80.19%

Absent and reverse end diastolic flow (AEDF/REDF):

Fetuses with absent and reverse end diastolic flow were at a significantly increased risk for delivery at low gestation, IUGR, low birth weight and perinatal deaths. In patients of PIH there is an increased risk of serious diseases affecting the infants' central nervous system, lung or intestine.[13] In the present study all the four babies with AEDF were admitted to NICU and there was no perinatal death. But out of 3 babies with REDF, one required NICU admission and the remaining two were stillborn resulting into mortality rate of 66.67%.

Middle cerebral artery doppler studies:

It has high impedance low flow circulation and is a more sensitive parameter of fetal oxygenation status than umbilical blood flow. Fetal middle cerebral artery S/D showed a gradual decline in the mean value from 6.28 at 28 weeks to 4.2 at 40 weeks. Similarly, MCA RI showed a decline from 0.84 at 28 weeks to 0.75 at 40 weeks. MCA PI mean value fell from 2.09 at 28 weeks to 1.4 at 40 weeks.[8]

In the present study, the specificity and positive predictive value of MCA S/D ratio in detecting adverse perinatal outcome are 97.10% and 81.82% respectively. Lakhkar BN in his study concluded that S/D ratio of MCA/UA is the most sensitive and specific index in predicting perinatal adverse outcome.[9]

Cerebroplacental ratio (CPR): MCA/UA P.I.

CPR is the ratio of the MCA to UA Pulsatility index. CPR compare the resistance to blood flow in the umbilical artery and the MCA. It measures the proportion of flow supplying the brain and the placenta. The CPR is a possibly better predictor of adverse outcome than the ratio in either of the vessels on their own.[14]

In the present study, abnormal cerebroplacental ratio was found in 80% of the babies admitted to NICU. It was found that 70.6% of babies with low Apgar score (less than 7) at 5 minutes were having abnormal cerebroplacental ratio.

The present study findings are comparable with Ozeren et al Gramellini et al and Fong et al who concluded that cerebroplacental ratio is having high positive predictive value when compared to MCA PI and UA PI. In the similar study by Rozeta Shahinaj, they found high sensitivity of MCA/UA PI ratio in predicting stillbirth (Table 8).[7,11,15,16]

The diagnostic accuracy of cerebroplacental ratio in the present study was found to be 80.19% which was followed by UA PI and the MCA PI, 70.75% and 63.21% respectively.

Uterine artery doppler studies:

Evaluation of these arteries at 23-25 weeks of gestation has been proposed as a useful test in screening of risk of preeclampsia and IUGR. However, in the present study the association of abnormal uterine artery Doppler findings were correlated with the adverse perinatal outcome.

In PIH there is inadequate invasion leading to increased resistance in spiral arteries. This leads to impedance of blood flow in uterine arteries.[5] Uterine artery S/D showed a gradual decrease from a mean of 2.2 at 28 weeks to 1.6 at 40 weeks. Whereas mean value of RI falls from 0.55 at 28 weeks to 0.37 at 40 weeks. Uterine artery PI mean value declines from 0.73 at 28 weeks to 0.53 at 40 weeks.[8]

Kofinas et al in his study yielded a sensitivity of 66% and specificity of 64% for uterine artery S/D. But when it was combined with umbilical artery S/D sensitivity increased to 75% and specificity increased to 100%.[17] Frusca et al in a retrospective study on 344 hypertensive pregnant women found abnormal uterine velocimetry was associated with worse pregnancy outcome.[18] Mohd Khalid et al in their study found that 94.44% hypertensive women showed abnormal uterine artery Doppler of which 32.25% had intrauterine growth restriction and one had Intrauterine death as fetal outcome.[8] In the present study uterine artery S/D Ratio had specificity of 89.86% in predicting abnormal perinatal outcome.

In the present study, uterine artery notch had a sensitivity and specificity of 56.76% and 89.86% respectively. Notch as single parameter yielded a PPV of 75%. However, in combination with other uterine artery Doppler indices it is a good indicator for prediction of adverse perinatal outcome. Kofinas et al in their study noted that the presence or absence of notching did not influence the results because when there was notching of the uterine artery, the uterine artery S/D ratio was above

the normal range in 87% patients.[17] Hazra et al in his study found that in patients with uterine artery early diastolic notch, 13% babies were still born and 25% neonates required NICU admissions.[19]

CONCLUSION

Multi vessel color Doppler ultrasound studies are important monitoring tools in patients with PIH to identify compromised fetuses in utero and to take timely appropriate action. In the present study, the findings of AEDF and REDF were associated with significant perinatal morbidity and mortality. All babies with AEDF required NICU admission whereas 66.7% babies with a REDF had succumbed to death. Hence AEDF and REDF are ominous sign in Doppler study and prompt action for intervention is necessary in these cases. In the present study cerebroplacental ratio showed highest sensitivity, specificity and diagnostic accuracy in predicting adverse perinatal outcome and is better than MCA PI and UA PI alone. Additional uterine artery Doppler evaluation is also helpful in predicting adverse pregnancy outcome. Considering the high specificity and diagnostic accuracy of all parameters in predicting adverse perinatal outcome, combination of various parameters can be useful in decision making process especially to decide the timing of delivery.

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