Original Research Article

Doppler interrogation of fetoplacental circulation in hypertensive disorder of pregnancy and their perinatal outcomes

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ABSTRACT

Background: Hypertensive disorders of pregnancy are one of the major causes of maternal morbidity-mortality leading to 10-15% of maternal deaths especially in developing areas of the world. The Doppler examination makes it possible by providing a unique, non-invasive and safe method of studying blood flow characteristics in both the fetoplacental and uteroplacental circulations that is being used in clinical evaluation of high risk pregnancies. The aim was to study early detection of fetoplacental compromise in hypertensive disorder of pregnancy with Doppler indices and to know its role in predicting perinatal outcomes and interventional strategies in these patients.
Methods: This prospective study was conducted on 100 subjects, 50 patients in study group with hypertensive disorders and 50 patients in control group with normotensive pregnancy. Doppler studies of umbilical and middle cerebral artery done and parameters recorded were systolic/diastolic ratio, pulsatility index and resistance index at 28-37 weeks of gestation. Perinatal outcomes of both groups compared, analyzed statistically. Multiple pregnancy, chronic hypertension, fetal congenital anomalies, systemic disease and those lost to follow up till delivery were excluded from study.
Results: Statistically significant difference in the incidence of induction of labour (p=0.012) and caesarean delivery (p=0.049), preterm delivery (p=0.004), low birth weight (p=0.003), low apgar score (p=0.045) and NICU admission in the patients with abnormal umbilical artery doppler of hypertensive group were seen .66.66% and 100% perinatal mortality seen in absent end diastolic flow and reverse end diastolic flow of umbilical artery in hypertensive group respectively.
Conclusions: Abnormal umbilical artery had highest sensitivity 76% and positive predictive value 84% in predicting adverse perinatal outcome and MCA Doppler having highest specificity 96% to exclude the false positive results of abnormal UA. The sequential study of both vessels useful in predicting interventional strategies and improving perinatal outcomes.

Keywords: Doppler, Fetoplacental circulation, Hypertensive pregnancy

INTRODUCTION

Hypertensive disorders of pregnancy are one of the major causes of maternal morbidity-mortality leading to 10-15% of maternal deaths especially in developing areas of the world.[1] It is also responsible for 18% of fetal (more than 19 weeks of gestation) and infant mortality as well as 46% of infant born small for gestation age.[2] The primary pathology is the impairment of placental perfusion result from insufficient invasion of maternal spiral arterioles by the trophoblast early in gestation. This leads to increased vascular resistance and decreased utero placental perfusion. The manifestations of pre-eclamsia in fetoplacental unit seen are FGR, oligohydramnios,

placental abruption, fetal hypoxia, non-reassuring fetal status and perinatal deaths. Predicting the risk of these complications may improve the outcome by providing appropriate antenatal surveillance and therapeutic interventions. The traditional methods of fetal surveillance like non-stress test, fetal heart monitoring and fetal biophysical profile are no more ideal tests because of their inability to detect early stages of fetal distress, significant number of false positive tests and low predictive value. Doppler examination makes it possible by providing a unique, non-invasive and safe method of studying blood flow characteristics in both the fetoplacental and uteroplacental circulations that is being used in clinical evaluation of high risk pregnancies.[3]

Antepartum fetal surveillance is based on the idea that identification and timed delivery of the hypoxic fetus can prevent intrauterine fetal death and decrease the risk of long term adverse effect. Our study is an effort at establishing the role of UA and MCA Doppler ultrasound in predicting adverse perinatal outcome in hypertensive disorders of pregnancy and to determine the role of Doppler velocimetry in clinical management of such pregnancies.

Aims and objective

- Early detection of fetoplacental compromise in hypertensive disorder of pregnancy with Doppler indices (Resistance index, pulsatility index and systolic/diastolic ratio)
- To evaluate the role of UA and MCA doppler indices in predicting the perinatal outcome and interventional strategies.

METHODS

The present prospective study was undertaken in the Department of Obstetrics and Gynecology in HINDU RAO HOSPITAL for one year after getting clearance by the Ethical Committee of our institution.

Hundred patients with inclusion criteria admitted/ attending to department of obstetrics and gynaecology were assigned into two groups A and B. Group A having 50 women with hypertensive disorder of pregnancy and group B included 50 women with normotensive pregnancy as control groups. Doppler evaluation done in all the patients at (28-32) weeks, (33-36) weeks and (37-40) weeks of gestation and more frequently in those patients who were clinically indicated to determine a favorable or a worsening trend in the Doppler indices after detailed clinical history and examination. The machine used was Philips HD 11XE Color Doppler ultrasound machine with a convex transducer of 2-5 MHz frequency. Doppler wave form was obtained after localizing the vessels by B mode real time scanner.

Inclusion criteria

- Any gravida with singleton pregnancy
- Diagnosed cases hypertensive disorder of pregnancy
- Women with POG 28-40 weeks

Exclusion criteria

- Multiple gestations
- Systemic diseases like chronic hypertension, chronic renal disease, SLE
- Fetal congenital anomalies
- lost to follow up till delivery

Doppler waveform analysis of umbilical artery and middle cerebral artery was done. The UA S/D, PI, RI ratios were considered abnormal if the value were above the 95th percentile of previously published values for gestational age and MCA S/D, PI, RI ratio was considered abnormal if the value was below the 5th percentile of previously published values for gestational age.[4] The women followed throughout pregnancy, delivery and early puerperium.

Pregnancy was considered to have "Adverse outcome" when any of the following complications were present

- Emergency CS for foetal distress or MSAF
- Prematurity (<37 weeks)
- Low birth weight (<2.5 kg)
- Low APGAR score ((5 min Apgar score less than 7)
- Admission to NICU for complications of low birth weight
- Perinatal or neonatal death

Perinatal outcome of both the groups were analyzed statistically by comparing the percentages of both the groups. The predictive power of different indices of UA and MCA were expressed by sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV) and accuracy.

RESULTS

In the hypertensive group abnormal doppler waveform were present in 42% of patients and only 10% in control group had abnormal doppler waveform. There was statistically significant difference in the incidence of abnormal doppler waveform among hypertensive and control groups (p=0.0001).

Adverse outcomes seen in 16(85.6%) out of 19 patients with abnormal UA S/D followed by UAPI 11 (73.33%) and UA RI 9 (69.23%). Incidence of abnormal S/D ratio, PI and RI of MCA were 14% and 10% each in hypertensive group with abnormal doppler.

Table 1: Distribution on the basis of incidence of abnormal doppler waveform.

Doppler waveform	Hypertensive group		Control group	
	No. of patients	%	No. of patients	%
Normal doppler	29	58%	45	90%
Abnormal doppler	21	42%	5	10%
Total	50	100%	50	100%

Table 2: Distribution of abnormal doppler waveform of umbilical artery and MCA.

Abnormal umbilical A. indices	Hyprtensive group		Control group		P-value
	Abnormal umbilical artery	Adverse outcomes	Abnormal umbilical artery	Adverse outcomes	
Umbilical A. PI	15	11 (73.33%)	2	1	P=0.002
Umbilical A. RI	13	9 (69.23%)	2	1	P=0.008
Umbilical A. S/D	19	16 (84.21%)	3	1	P=0.0001
MCA PI	5 (10%)	5 (100%)	0	0	P=0.041
MCA RI	5 (10%)	4 (80%)	0	0	P=0.012
MCA S/D	7 (14%)	6 (85.6%)	0	0	P=0.022

Table 3: Perinatal outcomes in absent and reverse umbilical artery doppler in hypertensive groups.

Spectral characteristic	No. of patients	IUD	Neonatal death	Mortality
AEDF	3	2	0	66.66%
REDF	1	0	1	100%

There was statistically significant difference in all the abnormal indices of umbilical artery in hypertensive group and control group (p=0.0001).

Perinatal mortality was seen in 66.66% with absent diastolic flow in UA and 100% with reverse diastolic flow in UA in Hypertensive group.

A statistically significant difference in the induction of labour 19 (38%) vs 11 (57.89%) (p=0.017), caeserian rate 9 (47.36%) vs 1 (20%) (p=0.049), preterm birth 11 (57.89%) vs 1 (20%) (p=0.03), FGR 10 (52.63%) vs 1 (20%) (p=0.03), Babies with meconium stained liquor 11 (57.89%) vs 1(20%) (p=0.022) was seen between the hypertensive group and control group.

Table 4: Doppler velocimetry of umbilical artery and perinatal outcomes.

Perinatal outcome	Hypertensive group		Control group		P-value
	Normal doppler	Abnormal doppler	Normal doppler	Abnormal doppler	
Induced labour	9 (29.03%)	11 (57.89%)	10 (21.27%)	1 (20%)	0.012
LSCS	9 (29.03%)	9 (47.36%)	8 (17.02%)	1 (20%)	0.049
Preterm	9 (29.03%)	11 (57.89%)	8 (17.02%)	1 (20%)	0.03
LBW	7 (22.58%)	10 (52.63%)	7 (14.89%)	1 (20%)	0.03
AP<7	6 (19.35%)	9 (47.36%)	6 (12.76%)	1 (20%)	0.045
NICU admission	8 (25.80%)	9 (47.36%)	5 (10.63%)	1 (20%)	Not significant
NICU stay>48 hours	4 (12.90%)	7 (36.84%)	4 (8.51%)	1 (20%)	Not significant
Meconium stained liquor	2 (6.45%)	11 (57.89%)	3 (6.38%)	1 (20%)	0.022
IUD	0	3 (15.78%)	0	0	Not significant
Neonatal death	0	1 (5.2%)	0	0	Not significant
Total	31	19	47	3	

Table 5: Diagnostic index of umbilical artery parameters as predictor of adverse perinatal outcomes.

Umbilical artery		Sensitivity	Specificity	PPV	NPV	Accuracy
PI	Hypertensive groups	68.75%	88.23%	73.33%	85.71%	66%
	Control groups	9%	97.43%	50%	79.18%	78%
RI	Hypertensive groups	64.28%	88.88%	73.33%	85.71%	62%
	Control groups	8.33%	97.36%	50%	77.18%	78%
S/D	Hypertensive groups	76.19%	89.65%	84.21%	83.87%	76%
	Control groups	18%	97.43%	66.66%	80.85%	80%

Table 6: Diagnostic index of abnormal MCA parameters as predictor of adverse perinatal outcomes.

Middle cerebral artery		Sensitivity	Specificity	PPV	NPV	Accuracy
PI	Hypertensive group	21.7%	96.29%	83.33%	59.09%	62%
	Control groups	0%	00%	00%	00%	00%
RI	Hypertensive groups	17.39%	92.59%	66.66%	56.81%	58%
	Control groups	00%	00%	00%	00%	00%
S/D	Hypertensive groups	25%	96.15%	85.71%	58.13%	62%
	Control groups	00%	00%	00%	00%	00%

DISCUSSION

Preeclampsia is known to be associated with adverse fetomaternal outcome resulting from utero- placental and feto-placental insufficiency. Doppler ultrasonography allows an objective assessment of blood flows in the fetomaternal and uteroplacetal circulation. It serves as an effective assessment tool that helps clinicians channel appropriate surveillance, care, intervention and resources to pregnancies at high risk.

We studied all the Doppler indices i.e. RI, PI, S/D of umbilical artery and middle cerebral artery from 28 weeks of gestation to term. The adverse outcomes we studied were preterm deliveries, FGR, low APGAR score, NICU admissions, NICU stay >48 hours, perinatal death and caesarean sections. In study group maximum number of patients (48%) were in the 26-30yrs age group out of these 64% were primigravida while in the control group only 36%. Khalid et al showed 77.77% patients in preeclampsia group were primigravida while in control group 54.5% were primigravida[5]. Prepregnancy BMI is an independent risk factor for PIH and their adverse effect. In the current study, mean BMI of study group was (25±3.34) and of control group was (23±2.75). Asim et al found that pregnancy induced hypertension was two times more likely in obese women than non-obese women.[6]

Present study enrolled 100 patients in which 50 were hypertensive out of which 21/50 (44%) patients had abnormal Doppler studies and 29/50 (56%) had normal Doppler parameters. Similar trend was seen in other studies.

Present study showed that the mean S/D ratio, PI and RI of umbilical artery Doppler decreased throughout as gestational age advanced but values in the hypertensive group were higher than the normotensive group emphasizing the fact that there was increased uteroplacental resistance in these women. Saxena et al showed similar results in their study.[10]

Table 7: Studies showing percentage of abnormal doppler in hypertensive disorders of pregnancy

Author	Normal doppler	Abnormal doppler
Bhatt et al[7]	44%	56%
Gupta et al[8]	45%	55%
Srilakshmi et al[9]	32%	68%
Present study	56%	44%

Of the 21 patients with abnormal Doppler, 19 (38%) had abnormal umbilical artery values and 7 (14%) showed abnormalities in the MCA flows. Out of 19 patients with abnormal UA S/D 16 (84.21%) had adverse outcomes and out of 14 patients with abnormal UA PI 11 (73.33%) had adverse outcomes and only 9 (69.23%) patients were presented with adverse outcomes out of 11 with abnormal UARI. While in control group abnormal umbilical artery indices were seen only in 3 (6%) normotensive women.

A statistically significant difference in the induction of labour 19 (38%) vs 11 (57.89%) (p=0.017), caeserian rate 9 (47.36%) vs 1 (20%) (p=0.049), preterm birth 11 (57.89%) vs 1 (20%) (p=0.03), FGR 10 (52.63%) vs 1 (20%) (p=0.03), Babies with meconium stained liquor 11 (57.89%) vs 1 (20%) (p=0.022) was seen between the hypertensive group and control group. Out of 16 fetuses with abnormal umbilical artery Doppler in hypertensive group, 11 babies were born with meconium stained liqour out of which 9 were born with apgar<7 at 5 min and all

these were admitted to NICU. Out of these, 2 were discharged on 2nd day and 7 (47.36%) required NICU care for more than 48 hours. But in control group only one baby with abnormal flow on Color Doppler was admitted to NICU for prematurity and meconium stained liqour and discharged on 2nd day. Smitha et al (2014) reported low apgar score in 34.7%, NICU admission in 45.65%, IUD in 21.74% and perinatal death in 6.52% with abnormal umbilical artery flow in PIH group.[11] Srilakshmi et al were noted 70% LBW, 48% preterm deliveries, 38% NICU admission and 16% neonate with less apgar score in study group with abnormal umbilical artery flow.[9]

Table 8: Different studies showing high perinatal mortality in AEDF and REDF.

Author	Mortality in % (AEDF)	Mortality in % (REDF)
Bhatt et al[6]	50%	50%
Lakhar et al[12]	100%	100%
Smitha et al[11]	27.78%	100%
Srilakhshmi et al[9]	100%	100%
Present study	66.66%	100%

In present study, out of 21 abnormal Doppler flows, 3 patients had absent diastolic flow and one had reversal of flow in umbilical artery. Two of these fetuses died in utero (at <30 weeks) with absent diastolic flow. Thus a high perinatal mortality of 66.66% was noted. One baby with reversed diastolic flow died in NICU in early neonatal period due to meconium aspiration syndrome. In control group there was no case with absent or reversed diastolic flow in the umbilical artery.

Many researchers have shown, time and again that absent and reversed diastolic flow in the umbilical artery is associated with high perinatal mortality and morbidity.

Meta-analysis from the Cochrane database syst Rev 2013 showed the use of Doppler ultrasound in high-risk pregnancy was associated with a reduction in perinatal deaths (risk ratio (RR) 0.71, 95% confidence interval (CI) 0.52 to 0.98. There were also fewer inductions of labour and fewer caesarean sections.

No difference was found in operative vaginal births nor in Apgar scores less than seven at five minutes.[13] Cochrane database syst Rev 2015 does not provide conclusive evidence that the use of routine umbilical artery Doppler ultrasound, or combination of umbilical and uterine artery Doppler ultrasound in low-risk or unselected populations benefits either mother or baby.[14]

The current study has shown that absent or reversed end-diastolic flow in the umbilical artery was strongly associated with major perinatal morbidity with mortality. This has been well recognized in the literature that there is strict correlation between the abnormal UA and poor perinatal outcome.

Table 9: Predictive power of umbilical artery doppler shown by different studies.

Author	Index	SS	SP	PPV	NPV	Accuracy
Ozeren et al[15]	PI	69%	97%	95%	81.0%	
Gramellini et al[16]	PI	64%	90.7%	72.7%	86.7%	65.5%
Goyal et al[17]	S/D	65.21%	57.4%	83.33%	33.33%	76%
	PI	41.30%	50%	83.33%	41.37%	62%
	RI	45.65%	78.57%	87.5%	23.91%	64%
Lakhar et al[12]	S/D	75%	41.3%	25%	86.3%	48%
	PI	58%	56.5%	35%	86.8%	56.8%
	RI	58%	71.7%	35%	86.8%	68.9%

Table 10: Present study showing predictive power of umbilical artery doppler.

Author	Indices	Group	SS	SP	PPV	NPV	Accuracy
Present study	PI	Study group	68.75%	88.23%	73.33%	85.71%	66%
		Control group	9%	97.43%	50%	79.18%	78%
	RI	Study group	64.28%	88.88%	73.33%	85.71%	62%
		Control group	8.33%	97.36%	50%	77.18%	78%
	S/D	Study group	76.19%	89.65%	84.21%	83.87%	76%
		Control group	18%	97.43%	66.66%	80.85%	80%

Of the 19 hypertensive gravidas with abnormal umbilical artery flow, 16 had pregnancy outcomes that were adverse in one or more ways (sensitivity of 76.19 % and positive predictive value of 84.21%) but in control group

only one pregnancy suffered adverse outcome out of the 3 abnormal umbilical artery flows detected. All the indices of umbilical artery had better sensitivity and positive predictive value in hypertensive group than in the control group.

The study thus highlights that umbilical artery study is more useful in high risk pregnancy for prediction of adverse outcome than in low risk group. Various studies showing the predictive value of umbilical artery in predicting the adverse pregnancy outcome.

Patients with abnormal middle cerebral artery indices

Redistribution of blood flow occurs at an early stage in fetal adaptation to hypoxemia (brain-sparing reflex), where in there will be an increased end diastolic flow resulting in decrease in S/D ratio, PI and RI. The present study reaffirms the fall in the MCA resistance with an elevated umbilical artery resistance as gestation advances in hypertensive gravidas.

In study group out of 21 patients with abnormal Doppler, 7 (14%) patients had abnormal MCA S/D ratio and 5(10%) patients had abnormal MCA PI and MCA RI each. Adverse outcome seen in all patients (100%) with abnormal MCA PI, 4 (80%) patients with abnormal MCA RI and 6 (85.71%) with abnormal MCA S/D. No normotensive women had abnormal MCA values.The study stresses the fact that abnormal MCA indices had high specificity (96.15%) but very low sensitivity (25%) for predicting the adverse perinatal outcome in hypertensive women.

Similar sensitivity and specificity has been described by many authors.

Table 11: Predictive power of MCA doppler shown by different studies.

Author	Indices	SS	SP	PPV	NPV	Accuracy
Smitha et al[11]	MCA PI	86.24%	50.63%	62.23%	84.24%	64%
Lakhar et al[12]	MCA	41.6%	90.9%	88.2%	48.7%	
Gramellini et al[18]	MCA	24%	100%	100%	77.7%	
Goyal et al[16]	MCA S/D	48%	85.71%	92.3%	33.33%	72%
	MCA PI	47.82%	92.85%	95.65%	35.13%	70%
	MCA RI	28.46%	71.42%	87.5%	35.71%	76%
Present study	MCA S/D	25%	96.15%	85.71%	58.13%	62%
	MCA PI	21.7%	96.29%	83.33%	59.09%	62%
	MCA RI	17.39%	92.59%	66.66%	56.81%	58%

CONCLUSION

Analysing the parameters interrogated in our study of utero-feto-pacental circulation. The umbilical artery S/D ratio had maximum sensitivity (76%) in predicting adverse perinatal outcome in high risk pregnancies. Maximum specificity was observed for MCA. Hence multi vessel colour doppler evaluation is more comprehensive in detecting fetoplacental jeopardy and imminent compromise.

Doppler flow parameters follow a sequential mapping of Doppler flow indices reveal a definitive pattern of early changes in the umbilical artery reflecting downstream resistance preceding upstream indicial changes in the middle cerebral artery flow parameters. A significant association between abnormal Doppler indices in hypertensive pregnancies and compromised fetomaternal outcome was found and compared with control.

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