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Original Research Article

The role of color Doppler and spectral flow analysis in the management of pregnancy induced hypertension

Nehal S. Diwanji[1]*, Alpesh D. Pancholi[2], Mona Shastri[1]

[1]Department of Radio diagnosis, Surat Municipal Institute of Medical Education and Research, Surat, Gujarat, India
[2]Department of Radio diagnosis, Consultant Radiologist, Surat, Gujarat, India

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***Correspondence:**
Dr. Nehal S. Diwanji,
E-mail: rockki1234@gmail.com

ABSTRACT

Background: Nearly one third intrauterine death of normally formed singleton fetuses are associated with IUGR coexisting with or without pregnancy induced hypertension (PIH). Abnormal fetal circulation is considered a major factor in fetal growth restriction, both as a cause and an indicator. Doppler ultrasound is a relatively new technique which merits investigations as a screening method for IUGR and PIH as both are associated with placental vascular pathology. The development of Doppler ultrasonographic technology, particularly during last 10 years, has provided an opportunity to obtain both qualitative and quantitative assessment of maternal and fetal hemodynamics using a non-invasive method. Objectives were to assess the role of color Doppler and spectral flow analysis in the management of pregnancy induced hypertension.

Methods: It was a prospective observational study in which 50 pregnant women were taken as cases with pregnancy induced hypertension and 25 as matched controls without any high-risk factor. All patients were examined for colour Doppler spectral flow analysis. Detailed USG results in the form of maturity by biparietal diameter, head circumference, femoral length, abdominal circumference, liquor, and expected fetal weight were measured and noted. Doppler study of umbilical artery, fetal middle cerebral artery, both maternal uterine arteries and ductus venosus was carried out. Parameters in the form of resistive index (RI), pulsatility index (PI) and systolic/diastolic ratio (S/D) of all four arteries were taken. In ductus venosus waveform, changes in the 'a' wave were noted. All participants were followed up from the point of the recruitment up to the time of delivery. At the time of delivery, the mode of delivery, any complications, the Apgar score, weight of the baby, birth asphyxia and admission in NICU were noted.

Results: The number of patients with PIH were highest in the age group of 21-25 years [n=31 (62%)]. IUGR of fetus occurred in 74% of the cases with PIH, while no any patients with IUGR fetus among the control group. 92% patients among uterine notches showed abnormal fetal outcome in the form of low birth weight, preterm delivery, LSCS for fetal distress, birth asphyxia or NICU admission of the neonate. Out of total 37 (74%) IUGR cases, 24 (65%) cases had fetoplacental Doppler abnormality. Out of total 6 cases with absent end-diastolic flow (AEDF) 4 cases had abnormal fetal outcome and 2 cases had delivered still-born babies. 20 out of 30 cases had abnormal fetal middle cerebral arterial Doppler (MCA) PI, out of which 19 patients had abnormal fetal outcome. 23 cases had abnormal CPR, out of them 20 (87%) cases had abnormal outcome and only 3 cases had normal fetal outcome. The parameters at the time of delivery are number of cases with delivery before 37 weeks of GA (63.3%), SGA babies (70%), LSCS for fetal distress (43.3%), and NICU admission (43.3%).

Conclusions: Examining the maternal vessels using Doppler ultrasound, it is possible to determine the risk of complication developing in the course of pregnancy long before clinical signs of preeclampsia appear, so that therapeutic measures may be undertaken early.

Keywords: Color Doppler examination, Pregnancy induced hypertension, Spectral flow analysis, Umbilical artery, Uterine artery

INTRODUCTION

The most beautiful period of a woman's life is "being a mother" that golden period of nine months which she wants to spend happily without any complications. The recent advances in medical profession take good care of all pregnant females. The course of pregnancy is continuously monitored by clinical examination and laboratory investigations at specific intervals throughout pregnancy. Doppler ultrasonography has been recently introduced in the study of the fetal circulation and various vessels including the both uterine artery, umbilical artery, and middle cerebral artery.

The use of Doppler ultrasound to study blood flow in obstetrics is of major importance because fetal inaccessibility precludes many other methods of study of fetal circulation.[1] The development of Doppler ultrasonographic technology, particularly during last 10 years, has provided an opportunity to obtain both qualitative and quantitative assessment of maternal and fetal hemodynamics using a non-invasive method.[2]

Perinatal complications have been found to be statistically correlated with abnormal indices of flow resistance, suggesting a potential role of Doppler ultrasound in the management of high risk pregnancies.[3] No evidence has emerged to support the use of Doppler studies in the general obstetric population, however it is mainly of use in a selected group of women, namely those with hypertensive diseases and/or those where a small for gestational age (SGA) fetus is suspected.[3]

Intrauterine growth restriction (IUGR) is associated with significant perinatal mortality and morbidity.[4] Adequate management of this condition requires an early recognition of fetuses who are SGA. Abnormal fetal circulation is considered a major factor in fetal growth restriction, both as a cause and an indicator. A proportion of these may have growth retardation and therefore are at greater risk of hypoglycemia, hypothermia, fetal distress during labor, and admission to neonatal intensive care unit (NICU). One of the main challenges is to distinguish normally nourished small fetuses from fetuses with true IUGR secondary to malnutrition and uteroplacental insufficiency. Accurate assessment of fetal condition may have a favorable effect on perinatal mortality and morbidity so that the fetus may be delivered before the occurrence of irreversible damage.

It is suggested that 36% intrauterine death of normally formed singleton fetuses are associated with IUGR coexisting with or without pregnancy induced hypertension (PIH). Abnormal fetal circulation is considered a major factor in fetal growth restriction, both as a cause and an indicator. Doppler ultrasound is a relatively new technique which merits investigations as a screening method for IUGR and PIH as both are associated with placental vascular pathology.[3] In a study, fetal arterial waveform indices have been shown to be superior to single values of abdominal circumference and estimated fetal weight.[4] More recent studies have suggested that ratios of Doppler waveform indices may further improve this prediction.

PIH is one of the commonest causes of high risk pregnancy. The Department of Obstetrics and Gynecology, Medical College and S.S.G. Hospital, Vadodara, Gujarat, India is the largest referral center in the central Gujarat catering to high risk obstetrics patients and they are sent to the department of radiodiagnosis for assessment. Keeping that in mind, the study was framed to assess the role of color Doppler and spectral flow analysis in the management of pregnancy induced hypertension.

METHODS

A prospective observational study carried out in the Department of Radiodiagnosis, Medical College and S.S.G. Hospital, Vadodara, Gujarat, India over a period of 2 years. The study was conducted with the help of Department of Obstetrics and Gynecology. The study was started after the approval of Human Research Ethics Committee.

A total 75 patients were selected from the outpatient department and indoor admissions from the antenatal ward. Out of all the patients, 50 were taken as cases and 25 as controls. Selection criteria for cases and control were as follows:

Selection criteria for cases

- Subjects with singleton pregnancies and gestational age of 28-40 weeks in the reproductive age group, who were sure of their last menstrual period or had dating scan in first trimester.
- Patients with pregnancy induced hypertension with or without clinical evidence of an SGA fetus.
- A previous anomaly scan should have been performed to exclude major congenital anomaly.

Selection criteria for controls

- After selection of cases, the controls were selected such that they matched the cases for the gestational age, parity and maternal age and had no high-risk factors.
- During the follow-up period the controls proceeded as uncomplicated pregnancies. If they developed high risk factors they were excluded from the study.

Details of obstetrics history, age, last menstrual date and underlying risk factors were noted. All patients were examined on Esaote AU5 colour Doppler machine with 3.5 MHz curvilinear probe and with colour and spectral Doppler. Detailed USG results in the form of maturity by biparietal diameter, head circumference, femoral length,

abdominal circumference, liquor, and expected fetal weight were measured and noted. Doppler study of umbilical artery, fetal middle cerebral artery, both maternal uterine arteries and ductus venosus was carried out. Parameters in the form of resistive index (RI), pulsatility index (PI) and systolic/diastolic ratio (S/D) of all four arteries were taken. In ductus venosus waveform, changes in the 'a' wave were noted.

Follow up Doppler study was done in required patients at 7 days or 15 days according to the previous Doppler findings. The patients enrolled for the study were followed up from the point of the recruitment up to the time of delivery. At the time of delivery, the mode of delivery, any complications, the Apgar score, weight of the baby, birth asphyxia and admission in NICU were noted. All data were tabulated and statistical analysis was performed using descriptive statistics of the collected data.

Above all measurements were taken in analysis.

RESULTS

The present study was carried out over a period of two years. During this period 50 cases with pregnancy induced hypertension and 25 controls without any risk factors were included in the study. Doppler study of maternal uterine arteries, umbilical artery, middle cerebral artery and ductus venosus was done; according to need follow up of the same was done at 7 days or 15 days' interval. The outcome of pregnancy in the form of IUGR, IUD, still birth, mode of delivery, birth asphyxia and NICU admission is was taken. Doppler study of the ophthalmic arteries was also done in the females with PIH, in which 14 patients were taken as cases and 14 as controls (without any risk factors).

Table 1: Age wise distribution of participants.

Age group (yrs)	Cases (n=50)		Controls (n=25)
	Mild PET (n=28)	Severe PET (n=22)	
16-20	6	3	3
21-25	20	11	15
26-30	1	3	6
31-35	1	4	1
36-40	0	1	0

Table 2: Mean fetal weight by ultrasonography at different gestational age.

Gestational age	Mean fetal weight (gm)	
	Cases	Controls
26-30	923.66	1069.4
31-35	1396.67	1886.7
36-40	1943.9	2665

As seen in Table 1, the highest numbers of patients were in the age group of 21-25 years (n=31 (62%) in cases, n=15 (60%) in controls). Mean fetal weight was more in control group at all the gestational ages. (Table 2) IUGR of fetus occurred in 74% of the cases with PIH, while there were no females with IUGR fetus among the control group.

Table 3: Bilateral uterine artery notch and fetal affection and abnormal fetal outcome.

Bilateral uterine artery notch (24 out of 50)	Fetal affection	
	Present	Absent
	22 (92%)	2 (8%)
	Fetal outcome	
	Abnormal	Normal
	22 (92%)	2 (8%)

Table 4: Fetal outcome in cases of bilateral uterine artery notch in relation to umbilical arterial Doppler.

	Umbilical arterial Doppler	Fetal outcome	
		Normal	Abnormal
Bilateral uterine artery notch (n=24)	Normal (n=11)	2 (18%)	9 (82%)
	Abnormal (n=13)	0	13 (100%)

Table 5: Comparison of fetal outcome in cases and controls in relation to umbilical artery S/D ratio and umbilical artery PI.

		Fetal outcome	
		Normal	Abnormal
Umbilical artery S/D ratio			
Cases (n=43)	Normal (≤3)	9 (21%)	11 (26%)
	Abnormal (>3)	5 (11%)	18 (42%)
Controls (n=25)	Normal (≤3)	21 (84%)	2 (8%)
	Abnormal (>3)	1 (4%)	1 (4%)
Umbilical artery PI			
Cases (n=50)	Normal (≤95th centile)	13 (26%)	17 (34%)
	Abnormal (>95th centile)	1 (2%)	19 (38%)
Controls (n=25)	Normal (≤95th centile)	22 (88%)	3 (12%)
	Abnormal (>95th centile)	--	--

24 out of 50 cases showed bilateral uterine artery notches, out of this 92% cases were associated with fetal affection in the form of IUGR or fetoplacental insufficiency as evident by abnormal umbilical artery seen by Doppler or MCA Doppler. 92% patients among uterine notches showed abnormal fetal outcome in the form of low birth weight, preterm delivery, LSCS for fetal distress, birth

asphyxia or NICU admission of the neonate. (Table 3) 13 (54%) cases showed abnormal umbilical arterial Doppler indices, out of which all cases had abnormal fetal outcome. In cases with normal umbilical arterial Doppler, 9 (82%) cases had abnormal fetal outcome. (Table 4) Also 7 cases had abnormal umbilical arterial Doppler with normal uterine artery Doppler. Among them, 6 cases had abnormal fetal outcome. Conversely, looking at IUGR cases, out of total 37 (74%) IUGR cases, 24 (65%) cases had fetoplacental Doppler abnormality.

In the case group (43), there were 23 cases with abnormal umbilical artery S/D ratio, out of which 18 cases had abnormal fetal outcome and 5 cases had normal fetal outcome. 20 cases had normal S/D ratio of which 11 cases had abnormal fetal outcome and 9 cases had normal fetal outcome. In the control group, out of 23 cases with normal umbilical S/D ratio, 21 cases had normal fetal outcome. 20 patients from the case group had abnormal umbilical artery PI, out of which 19 cases had adverse fetal outcome. In the control group, all patients had normal umbilical artery PI, out of which 3 patients had adverse fetal outcome (Table 5).

There were total 6 cases with absent end-diastolic flow (AEDF) in umbilical artery and 1 case with reversed end-diastolic flow (REDF) in umbilical artery in the present study. In AEDF group, 4 cases had abnormal fetal outcome and 2 cases had delivered still-born babies. In one case with REDF, the outcome was still-birth.

Table 6: Fetal outcome in cases of normal and abnormal umbilical arterial Doppler in relation to fetal middle cerebral arterial Doppler.

	MCA PI value	Fetal outcome	
		Normal	Abnormal
Abnormal Umbilical Doppler (n=30)	Normal (>5th centile)	5 (50%)	5 (50%)
	Abnormal (<5th centile)	1 (5%)	19 (95%)
Normal Umbilical Doppler	Abnormal (<5th centile)	2 (29%)	5 (71%)

As seen in Table 6, 20 out of 30 cases had abnormal fetal middle cerebral arterial Doppler (MCA) PI, out of which 19 patients had abnormal fetal outcome. Only 7 cases had abnormally low PI of MCA with normal umbilical arterial Doppler indices, out of which 5 patients had abnormal fetal outcome. Cerebroplacental ratio was calculated by dividing PI of MCA by PI of umbilical artery and it should normally be more than one. So here CPR less than 1 was considered as abnormal. In present study 23 cases had abnormal CPR, out of them 20 (87%) cases had abnormal outcome and only 3 cases had normal fetal outcome. In cases who had normal CPR (n=27), 59% cases had abnormal fetal outcome. Also 7 cases with abnormal ductus venosus Doppler findings showed abnormal fetal outcome.

Table 7: Fetal and neonatal parameters and Doppler indices in cases group.

Fetal and neonatal parameters	Doppler indices	
	Normal (n=20)	Abnormal (n=30)
Birth weight (gm)	2100	1582
Delivery <37 weeks	8 (40%)	19 (63.33%)
No. of SGA (small for gestational age)	8 (40%)	21 (70%)
LSCS for fetal distress	4 (20%)	13 (43.33%)
NICU admission	4 (20%)	13 (43.33%)
Avg. umbilical S/D ratio	2.60	3.95

Table 7 shows mean birth weight is significantly lower in abnormal Doppler indices group as compared to the normal group. Moreover, there were higher number of cases with delivery before 37 weeks of GA (63.3%), SGA babies (70%), LSCS for fetal distress (43.3%), and NICU admission (43.3%).

Table 8: Comparison of Maternal Ophthalmic arterial Doppler indices.

Subjects	Mean age of subjects	Mean GA	Mean PI	Mean RI	Mean Peak Ratio
Cases (n=14)	25	31.6	1.11	0.63	0.93
Controls (n=14)	24	29.79	1.36	0.69	0.63

As seen in Table 8, there is no significant difference between mean maternal age and mean gestational age of cases and controls. However, mean PI and RI were significantly lower in case group while peak ratio is significantly higher in the case group as compared to control group.

DISCUSSION

The age distribution of the participants suggests that higher number of patients (80%) with PIH were below 25 years of age. This is comparable to a collaborative study of hypertensive disorders of pregnancy by WHO which concluded that preeclampsia occurs more commonly during first pregnancy and in very young or older women, and when a woman has had preeclampsia in previous pregnancies.[5] In the present study 74% of PIH cases had IUGR. A study carried out by Bhatt et al supports this finding which showed that out of 100 cases of PIH, 60% had IUGR.[6]

In present study, 92% cases with bilateral uterine artery notch had fetal affection in form of IUGR or fetal hypoxia. The presence of a diastolic notch is a normal phenomenon up to 26 weeks of gestation. Presence of a notch after 26 weeks is a poor prognostic indicator leading to hypertensive and SGA complications.[7]

Imbalance of vasoactive substances not only causes vasospasm in the uteroplacental circulation in preeclamptic women, but also exerts a profound effect on the fetal circulation by raising vascular resistance and decreasing blood flow in growth-restricted fetuses. Bhushan et al evaluated 120 pregnancies and showed that among the uterine parameters the diastolic notch and PI showed the highest sensitivity, specificity, NPV and PPV values.[8]

In present study, 13 cases showed abnormal umbilical arterial Doppler indices, and all cases had abnormal fetal outcomes. Thus, we can say that abnormal fetoplacental circulation is more associated with adverse perinatal outcome as compared to abnormal uteroplacental circulation, whether it is associated with uteroplacental flow abnormality or not. Ghazali WAL and Chapman MG studied 271 normal pregnancy and 71 complicated pregnancies and they found that abnormal uterine artery tracing was of concern if found in combination with an abnormal umbilical arterial flow and so uterine artery flow was less sensitive than the umbilical artery Doppler in predicting fetal morbidity and this confirms findings of present study.[9] Trudinger et al studied that out of 53 cases of IUGR 34 cases (60%) had abnormal umbilical artery wave form. Which is comparable to present study and it suggests that abnormal umbilical artery Doppler study is associated with low birth weight fetuses and abnormal perinatal outcome.[10]

There were 23/43 cases with abnormal umbilical artery S/D ratio, out of which 18 cases had abnormal fetal outcome. 20 cases had normal S/D ratio of which 11(55%) cases had abnormal fetal outcome. So, we can say that umbilical arterial S/D ratio and PI have almost similar values in predicting abnormal fetal outcome and IUGR. Umbilical artery Doppler waveforms provide an estimate of downstream placental vascular resistance and placental blood flow. There is a strong association between reduced end-diastolic umbilical artery blood flow velocity and increased vascular resistance in the umbilicoplacental microcirculation.[11]

Ott WJ studied 578 pregnancies with umbilical artery S/D ratio and show that both AGA and SGA infants with abnormal Doppler studies had increased neonatal morbidity, with the SGA infants in this subgroup having the poorest prognosis.[12] McCowan et al suggested mothers of small for gestational age babies with abnormal umbilical artery Doppler velocimetry frequently delivered by cesarean section for fetal distress and were less likely to undergo induction of labor than those with normal Doppler.[13]

There were total 7 patients with AEDF/REDF in the umbilical artery, all of them had abnormal fetal outcome and out of them 3 (43%) had IUFD. This suggests that absence or reversal of diastolic flow in the umbilical artery is associated with the worst fetal outcome in the form of increased number of IUFD Various studies have shown that the risk of perinatal morbidity and mortality increases up to 60%, with increasing severity from reduced to reversed end-diastolic flow velocity.[14,15] Rochelson B, in his study of 151 high risk pregnancies found that all the cases in which there was absent end diastolic flow had adverse perinatal outcome and all delivered or died before 37 weeks and delivered babies spent more time in NICU.[16] Perinatal mortality was remarkably high at 40% in that study. This is comparable to present study in which mortality rate is 43%.

In the present study, total 30 patients had abnormal umbilical arterial Doppler indices. 20 out of 30 cases had abnormal MCA PI, out of which 19 (95%) patients had abnormal fetal outcome. 7 cases had abnormally low PI of MCA with normal umbilical arterial Doppler indices, out of which 5 (71%) patients had abnormal fetal outcome. Out of 27 cases with abnormally low PI in the fetal MCA, 20 were associated with abnormal umbilical arterial Doppler in which 95% cases had abnormal fetal outcome. Thus, isolated MCA has comparatively good fetal outcome. And cases in which umbilical artery was abnormal, almost all had adverse perinatal outcome. This suggests that umbilical artery Doppler findings are a better predictor of adverse perinatal outcome than an abnormal MCA. Recent studies suggest that the cerebroplacental Doppler ratio (CPR), is a better index for predicting adverse outcomes in IUGR when compared with either the umbilical artery Doppler values or the MCA values alone.[17,18] CPR reflects not only the circulatory insufficiency of the umbilical velocimetry of the placenta manifested by alterations in the umbilical S/D ratio but also the adaptive changes resulting in modifications of the middle cerebral S/D ratio.[19,20]

All cases with abnormal DV Doppler parameters like very small, absent or reversal of ‘a’ wave had abnormal fetal outcomes in the form of premature and SFD neonate. Out of them, 3 were still-born and rest cases were admitted in NICU for severe birth asphyxia. Umbilical vein pulsation and absent or reversed flow in the ductus venosus during atrial contraction have been reported as ominous signs of cardiac failure and perinatal mortality.[21,22]

From the Table 7, we can conclude that abnormal Doppler findings are associated with deliveries earlier than 37 weeks of gestation and adverse fetal outcome as well as increased perinatal morbidity and mortality. These findings are also supported by the study of Arora et al. They showed in their study that the average birth weight, diagnosis to delivery interval, and gestational age at delivery were comparatively lower with higher incidence of admission to neonatal intensive care unit in fetuses with abnormal umbilical Doppler velocimetry.[23]

In the present study, among the maternal ophthalmic arterial Doppler indices, mean PI and RI were significantly lower and peak ratio was significantly higher in the case group These findings are supported by

the various studies done in the past. Hata et al reported that the peak systolic flow velocity, end-diastolic velocity and time averaged-mean velocity in mild preeclampsia was significantly higher than that in normotensive pregnant woman.[24] They showed that the pulsatility index in women with mild preeclampsia was also significantly lower than that in normotensive pregnant women. Hata et al in the later study again reported that preeclampsia was associated with a significant decrease in ophthalmic artery vascular resistance, which is interpreted as orbital hyperperfusion or hyperemia.[25]

CONCLUSION

It can be concluded from the study that by examining the maternal vessels using Doppler ultrasound, it is possible to determine the risk of complication developing in the course of pregnancy long before clinical signs of preeclampsia appear, so that therapeutic measures may be undertaken early. One can also take decision timely regarding any intervention to be done before conditions appearing late during pregnancy.

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